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View of the Completed Lorimer Avenue Bridge, Pittsburgh, Pa., Looking North.

View Showing the Valley Over Which the Bridge is Carried.

THE LARGEST RE-ENFORCED CONCRETE BRIDGE IN AMERICA.—[See page 348.]

Theory of Mercury-Vapor Apparatus*

The Action of the Cooper Hewitt Lamp Construed on the Basis of the Electron Theory

By Percy H. Thomas

THE theory of the mode of operation of the well-known mercury-vapor apparatus, characterized by a hermetically sealed container exhausted to a high degree of purity and inclosing suitable positive and negative electrodes, is, more than that of most physical apparatus, dependent upon the aid of the electron hypothesis of the nature of electricity. The characteristic observed properties of this apparatus, as distinguished from the theory of its operation, are very simple in the fundamental embodiment and are well known.

As to the voltage consumed in a mercury-vapor device, it may be stated that the drop of potential is practically constant for values of current above a certain minimum regardless of the strength of the current, provided the vapor pressure of the mercury vapor is maintained constant. Of this constant voltage consumed in the device, there is a certain portion, also constant, consumed at each electrode, while the remaining constant portion is consumed in the passage of current through the vacuum or vapor space. Only this latter portion of the total drop is dependent upon the length and diameter of the vapor path.

The above statement as to voltage drop applies to the operating lamp. Before starting, the conditions are, however, entirely different. The device operates as though it contained somewhere a rigid obstruction to the flow of current, which obstruction substantially disappears when once overcome. A study of the behavior of this apparatus, particularly its behavior when utilized as a rectifier, points conclusively to the surface of the electrode impressed with potential in the negative direction, that is, to the cathode, as the location of this peculiar obstruction to the starting. This fact is established partly by the observed condition that the starting obstruction, or "reluctance," as it is called by Dr. Hewitt, can be overcome by various operations *at the surface of the cathode* and can not be overcome by any operations in any other part of the device, and is partly demonstrated by the fact that, with the device connected according to the ordinary method as a rectifier, namely, with two anodes connected to the terminals of the supply and the cathode connected to an intermediate point of the supply, current will flow freely in any direction in the vacuum space and will flow out of any electrode impressed with a positive potential and yet current will not flow between the two anodes, one or the other of which is always impressed with a positive potential while the other has a negative potential. Since now it is known that the anode impressed with the positive potential will not oppose the flow of current from the anode into the vapor and since it is known that current can flow in any direction through the vacuum space, it must follow that the reason the rectifier does not short circuit or "arc" between the anodes, in other words the reason that current does not flow directly between the main anodes, is the existence of some sort of obstruction or reluctance at the *anode impressed with the negative potential*, which is in fact the case.

One other characteristic property of the apparatus I wish to bring out, namely, that the voltage consumed in the vapor path proper depends upon the vapor pressure or density of the mercury vapor inside the container. Since there is liquid mercury in the inclosed space and no gas or vapor except the vapor of mercury, the pressure of the mercury vapor within must always be the pressure corresponding to the vapor tension of mercury at the temperature of the liquid mercury itself. This is seen to be true since, were the vapor pressure less than the appropriate value, the liquid mercury would evaporate until the pressure of saturation be reached and were the pressure in the vapor greater, vapor would be condensed until again the pressure of saturation corresponding to the temperature of the electrode be obtained. Therefore, the only way to increase or decrease the pressure in a mercury-vapor tube is to increase or decrease the temperature of the liquid mercury.

One more point. When mercury evaporates it absorbs heat; when it condenses it liberates heat, as in the case of any liquid in the pressure of its vapor; consequently, if heat be generated in liquid mercury within the condenser an equivalent amount of heat will be transferred to the coolest part of the wall of the container by the evaporization of mercury at the electrode and the condensation of mercury on the wall of the container. From this it follows that where two bodies of mercury, as for example two mercury electrodes, exist in the same device, they must necessarily have their surfaces at approximately the same temperature, since otherwise mercury would evaporate from the hot electrode, thus cooling it, and condense on the cold electrode, thus heating it. Many of the features and characteristics of mercury-vapor apparatus can be explained or understood by a knowledge of these principles. For example, the use of a condensing chamber as a means of controlling the temperature of the lamp, that is, that of the mercury cathode, the vapor pressure and the voltage consumed in the vapor path, may be clearly understood.

It is now in order to consider the electrical action of the operation of the device, which for the present discussion may be assumed to be a lamp. A flow of electricity, according to the electron hypothesis, to which I personally subscribe, is nothing more than the passage of electrons along a circuit. It is known that these electrons are physical bodies of extremely small mass, requiring between one and two thousand to give the mass of the hydrogen atom, and carry a definite negative electrical charge. These electrons exist in a relatively quiescent state in all matter. Since the charge carried by the electrons is negative and since unelectrified bodies show no resultant electric charge, it must follow that in such unelectrified matter the negative charge on the lectron is balanced by some positive charge in the material.

There will be no flow of electricity in an electric circuit, that is, no flow of electrons, until something disturbs the condition of electrical balance of the unelectrified matter. Whenever, however, the electron is separated from the positive charge which ordinarily neutralizes its external electrical effect and when there exists at the same time an electro-motive-force in the neighborhood of this electron, the electron will endeavor to follow the electro-motive-force and produce a flow of current. But electrons like other material particles or bodies can not move unless they have a free space in which to move. In all metal conductors it appears that there are passages or spaces between the atoms or molecules through which the electrons can pass relatively freely, although they will experience some resistance (the well-known ohmic resistance of the metals). Electrons set free in insulating material, however, do not find any passageways open for motion from one place to another, hence the electrons with their charges remain fixed in location. This is illustrated, for example, by the rod of sealing wax and the catskin. When rubbed by the skin the rod becomes electrified, but the electricity remains fixed in position. Under this condition the electrons are stuck, so to speak, in the insulating material.

Although air is ordinarily an insulator, it is generally assumed that air and other gases may be made under certain conditions to be good conductors of electricity and while, in a certain sense, that it true, it is, nevertheless, not analytically true. The principal reason that electricity does not flow through ordinary air and gases is that there are no free electrons in the gas to move in response to an electro-motive-force. When free electrons are introduced or produced in a gas, they do pass along through the gas if a suitable electro-motive-force is present. They pass, however, not through the atom themselves but in the space between them. This action is very much complicated, however, by the fact that part of the progress may be due to the movement of the molecules of the air itself and by the fact that electrons have an attraction for gas molecules and stick to them, sometimes collecting quite a group of molecules, called an aggregate. The transfer of electricity in the form of electrons, freed or liberated in air, is illustrated by the progress of a thunder cloud where the electric charges travel considerable distances with the air and probably to some extent through the air itself, slipping between the molecules. If electrons be set free from the atoms of the gas, as can be done with the aid of X-rays, and an electro-motive-force be applied, as was done by J. J. Thomson in his famous experiments in which he applied electro-motive-forces of opposite signs to parallel plates, there will be an actual flow of current through the air, due to the passage of electrons through the air. Such currents are always very small, however, since up to the present time no method has been devised for producing large quantities of free electrons from gases, under any such circumstances.

In the electric arc in air a large number of electrons are liberated from the cathode and force a lane or passageway to the anode, probably by crowding back the molecules of air.

The electron and its neutralyzing positive charge, when in a state of equilibrium and constituting a state of non-electrification, have an attraction for each other and can not be separated without the exertion of a considerable force and the expenditure of a certain amount of energy and ionization, as such separation is called, is ordinarily a difficult process. The forces being inter- or infra-automatic are very large in proportion to the physical size of the electrons. Furthermore, it is difficult to employ the powerful forces available in connection with large masses of matter in such a way as to be effective in separating the electrons from an atom. Electromagnetic waves of very short wave-lengths seem to be effective in producing this result. Ionization may be produced by such waves as are supplied by X-ray apparatus or by ultra-violet light. Another very effective method of producing ionization, that is, the separation of electrons from atoms, is the shock caused by the striking of one atom by another atom or by an electron proceeding at a very high velocity.

Electrons are always free and able to move within metallic conductors as long as they do not go outside.

Now the electric circuit containing a vapor electric device having a high vacuum between two electrodes may be considered. If an electro-motive-force be impressed in such a circuit the electrons will flow freely in the metal parts of the circuit from a point of low potential to the point of high potential (they move backward on account of their carrying a negative charge) until they reach some point where their progress is blocked, that is, where the electrons are not free to move. They are free to move, however, in all that part of the circuit constituted by metal conductors. Following the electrons within these metal conductors one finds them flowing freely toward the cathode of the device until they reach the surface of the cathode exposed in the vacuum. But the electron can not leave the surface of the cathode without overcoming the attraction of this electron for the corresponding positive charge associated with it. It could move freely in the body of the metal, since in leaving one positive charge, it could pick up another from an adjacent atom. These electrons then accumulate at the cathode surface, producing there a negative charge; similarly electrons are withdrawn from the anode, producing there a positive charge, which two charges impress the electro-motive-force of the circuit on the vapor path in the vacuum space. Now were there a supply of free electron in the vacuum space, they would be immediately drawn out of the vacuum space into the anode, producing a flow of current as long as the supply lasted. As has already been pointed out there is no material opposition or resistance to the *entering* of a metal conductor by a free electron, since no counter attraction for a positive charge must then be overcome. If, however, the electrons which have accumulated at the surface of the cathode could overcome the attraction they have for their positive charges and get into the vacuum space, they would leave the cathode and there would immediately be a stream of electrons between the electrodes in the vacuum space giving a flow of current, and there would be no limit to the amount of this current, unless a limit developed in the supply of electrons. But the supply of electrons is unlimited in the metals.

Now when a mercury-vapor lamp is started into operation, this means merely that a means has been provided for liberating electrons from the surface of the cathode. Then these electrons are free to flow under the influence of the electro-motive-force of the circuit from the cathode through the vapor path to the anode and into the anode through the metallic circuit outside, back through the cathode lead to the cathode again. In this circuit there is developed, of course, a certain amount of resistance in each part of the circuit; the well-known ohmic resistance in the metallic conductors; a certain resistance to the liberation of electrons at the cathode surface, and a certain resistance to the passage of electrons through the vapor space. This latter resistance, namely, the resistance to the passage of electrons (or current) through the vapor space results principally from the jostling and blocking of the electrons by the atoms or molecules of the vapor present which get in the path of the electrons. The lower the pressure of the vapor, the less this resistance and the less the voltage absorbed in the vapor path; the higher the vapor pressure, the greater the tendency to impede the progress of the electrons and the resistance of the lamp or its voltage drop.

In a lamp, however, it is this jostling of the vapor molecules that produces the light and the more vigorously they are jostled, that is, the greater the volume of the current flow and the greater the number of electrons, the greater the amount of light; and again the greater the number of vapor molecules, that is the greater the vapor pressure, the greater the amount of light.

After starting up a mercury-vapor lamp cold, although

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there is at first an abnormally large current, there is very little light produced. This is because there is very little vapor present and a relatively small number of vapor molecules are jostled. As the lamp warms up, however, although the current becomes somewhat less, the amount of light given is far greater, since the number of molecules of vapor is greatly increased on account of the higher vapor pressure.

The warming up process comes to a stage of equilibrium when the heat radiated or dissipated from the surface of the lamp equals the heat generated in the lamp. If now the heat dissipating capacity (for example by the use of a condensing chamber) of the device is so proportioned that this equilibrium is reached when the mercury temperature is somewhat above the boiling point of water one has a mercury-vapor lamp of the low-pressure type; if on the other hand the heat dissipating power of the lamp is reduced so that equilibrium is reached at a considerably higher temperature, there is obtained the high-pressure type of mercury-vapor lamp, the type for which a quartz container may be advantageously used.

Returning now to the surface of the negative electrode and the means by which the starting reluctance of the cathode is overcome and electrons are freed from the body of the cathode material, it is necessary to confess that the exact mechanism of this process is not known with certainty. A prominent characteristic feature of the process is, however, the so-called cathode spot or bright spot of light at the point where the electrons leave the cathode surface, which is one of the features distinguishing this light from the so-called Geisler tubes. At this spot something is going on which is liberating electrons from their associated positive charges in the atoms of the liquid mercury. It may be that the heat generated by the current flow concentrated at this point produces a very dense vapor and that the current which is greatly concentrated at this point serves to ionize this concentrated mercury vapor very energetically, this liberating of electrons serving to secure the continued flow of current in the vapor space. In any event there is some result of the flow of current at any one instant which provides for the liberation of electrons to constitute the flow of current during the next instant. Whether this be an extremely local heat effect or the rapid ionizing of vapor generated locally or whether it be the liberation of electrons directly from the liquid mercury by the bombardment of other electrons or positively charged atoms has not been determined. It is interesting to remember, however, that if there is an extremely plentiful ionization of vapor at the cathode spot there will be produced by the current flow first electrons which will be attracted to the anode and second, there will be liberated by these electrons the corresponding positively charged atoms, which will be attracted to the cathode by its negative charge. It may be that these latter atoms which must be continuously bombarding the cathode are the means of liberating electrons from the cathode to support the flow of current. However this may be, the fact can hardly be controverted that the essential action which eliminates the initial starting reluctance is closely related to some mechanism operating in the cathode spot and self-perpetuating when once started, as long as a flow of current in sufficient volume continues.

It is a well-known fact that if an attempt is made to start a flow of electricity through an extremely highly exhausted space that enormous potentials are required. It was customary originally to attribute this phenomenon to the supposed absence of a conductor in the vacuum space, but our present electron hypothesis has shown that electricity, that is electrons, being physical bodies move with the greatest facility in a vacuum and that the reason that the vacuum device resists the intial flow of current so stubbornly, is the fact that no means exist for liberating electrons within the vacuum space from the surface of the cathode, which is the only point at which they can be produced, since there is no gas or vapor in the vacuum which can be ionized to produce electrons. The high voltage required for starting in the high vacuum is to be expected, since it is only by forces acting directly on the *atoms themselves* that electrons can be produced from solid or liquid materials and a very high starting voltage must be provided, since it must be applied at a distance.

When, however, the vacuum in the device just discussed is not perfect and a certain residual gas is present, the high voltage applied to the terminals is sufficient to ionize the gas-producing electrons and positively charged atoms. These positively charged atoms, as already described, will be attracted to the cathode surface where they will bombard the material of the cathode, thus liberating further electrons and positive charges which repeat the process until under favorable conditions the permanent condition of current flow as already described is attained. The nature of these phenomena explains why the salient starting characteristics of the cathode in a vacuum are not observed in electrodes in the open air, at any rate to anything like the same extent as in the vacuum. The presence of the air between electrodes provides a source of electrons and positive charges automatically sufficient to liberate electrons from the cathode, whenever a suitable voltage is applied. Furthermore, the presence of the molecules of air in the path of the current when once started so greatly increase the *operating* voltage that the effect of the starting reluctance would be practically overshadowed.

With this exposition of the hypothesis or conception of the nature of the operation of a mercury-vapor device, which has satisfied me personally and seems consistent with practically all the fundamental principles now established in electro physics, as far as I know them, there remains very little to be said in explanation of the theory of operation of the practical mercury-vapor lamp, either the low-pressure lamp or the high-pressure lamp in the quartz container.

It may be well to call attention, however, to one characteristic of the quartz burner of great practical importance in its operation, though purely incidental in the electrical hypothesis involving its principle of operation. I refer to the fact that the quartz burner operating as intended in the Cooper Hewitt commercial quartz lamp is approximately a constant current device. That is, if the voltage applied in such a lamp is raised, the only effect is to increase the voltage on the tube without material change of current through the tube. Of course, the first momentary effect of the increase in voltage is an increase in the current, but this increase in current raises the temperature of the lamp, thus increasing the temperature of the mercury electrode and the pressure of the mercury vapor. This, in turn, increases the resistance of the lamp or the voltage consumed therein and the point of equilibrium is found finally at a current only slightly greater than the original current flow. Lowering of the voltage merely produces a lowered voltage on the tube when equilibrium is finally attained with but a slightly decreased current. These same characteristics are found in the low-pressure lamp, but are there not as marked. The particular significance of this phenomenon lies in the fact that if an attempt is made to adjust the series resistance of a high-pressure lamp, which is being installed to the proper value by the insertion of an ammeter in the circuit, it will be impracticable to make a satisfactory adjustment, since the difference between the current shown on the ammeter with a very low value of the series resistance and that with a very high value will be very slight, indeed. On the other hand, if a voltmeter be placed in shunt to the burner it is possible to adjust the series resistance with great accuracy and certainty, since the voltage on the burner is very sensitive to the proper setting. With the use of a voltmeter it is not necessary to pay any attention to the current, for this will take care of itself.

If it is for any reason desired to increase the current in a high-pressure burner (that is the tube) this must be done by increasing the natural dissipation of heat from the burner to give it a lower temperature, as by placing it in a cooler place or by directing a draft on the tube, or otherwise. In such a case the net result of the cooling is to lower the temperature of the electrode and the pressure of the mercury vapor. The result of the lowering of the voltage or the pressure is an increase in the current. This increase in the current will then heat up the burner until the vapor pressure and the burner voltage again bears the right relation to the supply voltage. Vice versa, when placed in an abnormally hot atmosphere the burner will take an abnormally small current. Thus, in very cold weather or with a cracked globe the tendency of a quartz burner is to take a large amount of current while its voltage may remain approximately normal.

Another result of this characteristic of the quartz burner is the difficulty of running the constant potential quartz burners in series; for suppose a number of such burners to be placed in a constant current circuit; some of them will naturally run a little hotter than others, either from variations in the structure or from different temperature conditions at their points of installation. Those naturally running hotter will be taking a little too much current and those running cooler will be taking too little current, but all are forced to take the same current, since they are a constant current circuit. Since now these devices are constant current devices, naturally those taking too much current will heat more and more and the hotter they tend to get (since the added vapor pressure and resistance from the added temperature increase the heat generated in the burner, even if there be no increase of current). It thus soon happens that a few burners take nearly all the potential and, perhaps, ultimately get so hot as to put out the whole series. The same general difficulty was originally met with in arc lamps, but was overcome by the use of shunt regulating coils coupled with means for adjusting the length of the arc between electrodes. The constant potential type of mercury quartz burner does not provide, however, for such adjustment and consequently this method is inapplicable.

A Theory of Vision

By M. Tscherning

Among the numerous points which the eye can see at the same time without moving, there is one point distinguished from the others. It is the "fixation point." It is difficult to say what characterizes this point. On looking at a surface of uniform brightness one has not the sensation that any one point is distinct from the others; but on marking a point on it, that sensation arises at once, whether it is fixed by the eye or not. If there are two points, one is sure which of them is fixed upon. We may diminish the distance between them as much as we please, but so long as we can see two distinct points, we can say which of them we are fixing. This shows that the fixation point must correspond to a single element of the retina. I call this element the "principal element," and the others, "accessory elements."

Consider the principal luminous element. With a normal, or "emmetropic" eye, a luminous pencil may be considered to emerge from it, and this pencil would, at some distance from the eye, encounter an object which it would illuminate. This is in accordance with the principle of the reversibility of light-rays, for the object really illuminates the retinal element. The cylindrical ray, or pencil, might be regarded as an invisible feeler or antenna, attached to the eye, and movable with it. This is true so long as the time taken by light to reach the eye from the object may be neglected. I call this antenna, which informs us concerning the external world, a "photophore."

We use the photophore very much as a surgeon uses a probe. What he feels is, in reality, the molecular vibration of the probe which he touches with his fingers; but he has the sensation of touching the walls of the cavity with the end of the probe. In the same way, we do not feel the ether vibrating against our retina, but we feel as if we touched the external objects with the end of our ether probe.

If we had only one photophore, we should be about in the position of the blind man who guides himself by feeling with his stick. The superiority of vision lies chiefly in the fact that we possess an enormous number of retinal elements, and therefore an enormous number of photophores, proceeding in all directions from the pupil. The accessory photophores can give us information concerning the form of external objects; but their chief task consists in directing our attention to one of the luminous points, which we then fix upon.

We should thus have to imagine the eye provided with an invisible cone-shaped apparatus, whose vertex is the pupil, and whose base is a sensitive mosaic, the outer image (clear or diffused) of the retina. This mosaic, which I shall call the "apparent retina," has the shape of the totality of objects visible at any one time It molds itself on them, as it were. A moment afterward, the direction of the eye changes, and the terminal surface changes, and so on. As the surgeon constantly moves the probe, we move the eye to explore the external world.

On looking round the room in which we are we say ordinarily the images of the walls and objects move over the retina. I should say, and with much reason, that we move our "apparent retina" over the objects. Although the comparison may appear strange, there is a great analogy between the manner in which the apparent retina informs us concerning objects and the manner in which the tongue informs us concerning the interior of the mouth. In both cases we explore the walls by means of a surface covered with a mosaic of sensitive points. As the mosaic is much finer in the yellow spot of the retina, so it is also at the tip of the tongue. What fundamental difference is there? The nature of the agent is different, of course. In one case we have the hardness, the degree of polish, of the surfaces. In the other case we have brightness and color. In one case we "feel," in the other we "see." But, apart from that, I see but one difference: the eye can "fix" a fine point, the tongue cannot.—Translation from *Comptes Rendus*, published in the *English Mechanic and World of Science*.

Experiments on Liquid Globules and Columns*

Peculiar Lifelike Motions Displayed by Drops of Liquid

By Chas. R. Darling, A.R.C.Sc.I., F.I.C.

If a large drop of liquid be formed in a shallow layer of water (after the manner described in a previous article),[1] so that the drop reaches the bottom of the vessel before parting, it will generally spread so as to take the shape of the lower portion of the vessel; and if the upper part of the drop be brought to the surface of the water, and the delivery tube be detached, a column of the liquid may form. In practice, however, it is not easy to obtain a liquid column in this manner; but by carrying out the following instructions the formation may be secured with ease and certainty: Take a test-tube 2.5 centimeters (1 inch) or more in diameter, and nearly fill the hemispherical end with water. Incline the tube, and pour *aceto-acetic ether* very gently down the side, until the level of the liquids rises about 1 centimeter in the cylindrical part. On erecting the tube, a column, similar to that shown in Fig. 1, will be formed, the upper part being attached to the surface of the water, while the lower end rests on the test-tube. The curved sides of the column will be seen to possess a most graceful outline, and are bounded by water. The shape of the column thus formed may be varied by employing a wider tube, in which case the column will be relatively narrower at the top; or by gradual additions of water, which stretch the column longitudinally, causing the diameter at the middle to diminish until breakage occurs. The change produced by adding successive small quantities of water is shown in Figs. 2 and 5, which represent four stages in the stretching of a column of *iso-butyl benzoate*. The varied outlines of the columns are extremely pleasing, and the last picture of the series shows the width at the moment of breakage, which in this case occurred during exposure, the column appearing in faint outline. After severance, the greater portion sinks to the bottom of the tube, the remainder hanging from the surface in the form of a globule. It may be added that the water should be allowed to trickle down the side of the tube, as, if dropped directly on to the column, water-bubbles are formed which impair the shape.

It might be expected that any liquid slightly denser than water would, if insoluble, form columns in the manner described. This is not the case, however, for reasons which at present cannot be entirely explained. Orthotoluidine, for example, does not lend itself to these formations; and in the case of aniline a vessel of 5 centimeters in diameter is required, and even then it is difficult to prevent the column from sticking to the side, and so spoiling the shape. Iso-butyl benzoate, as purchased, varies considerably; the first sample procured by the writer behaved ideally, as in Fig. 2, but three other specimens since obtained have entirely failed to produce satisfactory columns. Hence it is recommended, when it is desired to produce a column with certainty, to use aceto-acetic ether, which has given uniformly successful results.

MOVEMENTS OF LIQUID GLOBULES ON WATER SURFACE.

Investigations of movements on the surface of water have hitherto been restricted to the rotation of camphor and a few other solids, and to the formation of films of oil, which spread across the surface rapidly in all directions from the spot on which the oil is placed. While experimenting with aniline and orthotoluidine with a view to the formation of drops, the writer observed that the globules which floated on the surface of the water showed movements of a type not previously recorded and for which no satisfactory explanation has yet been given. So far no photographs have been secured which give an idea of the nature of the movements in question, and hence it will be necessary to resort to drawings in order that an idea may be formed as to the nature of the phenomena. The accompanying illustrations are the work of Mr. W. Narbeth, one of the writer's students, and correctly represents certain stages; but to observe the movements to full advantage it is necessary to perform the experiments. In order to produce surface globules, a dish, ten centimeters or more in diameter, is taken—a photographic dish answers well—and rinsed several times with tap-water before it is filled. One or two drops of the liquid under trial are then allowed to trickle down the side of the vessel on to the water, when globules, sooner or later, will form. A dropping bottle or fine pipette will be found convenient for regulating the quantity of liquid, which, if too large, may obscure the movements.

When a drop of red-colored, commercial aniline is thus floated on clean water, globules are formed which display movements best expressed by the word "twitching." What actually occurs is that the globule is stretched at first, but afterwards recoils, forming a globule of less diameter and greater depth. This alternate expansion and contraction is accompanied by the detachment of small globules from the rim, which becomes indented as shown in the largest globule depicted in Fig. 6, the small globules being formed from the protuberances. After shrinking, the appearance presented is indicated by the second largest globule in Fig. 6, which is shown surrounded at a distance by the small, detached globules. Finally, owing to continued partition at the rim, the diameter diminishes until, at a certain point, the movement ceases, leaving a number of small globules floating tranquilly on the water. If only a minute quantity of aniline be used, the globules may disappear entirely by spreading over the surface or by solution.

The next movement to be described is even more remarkable, and was first obtained by the author with orthotoluidine, but was only shown to perfection by one sample. Other quantities of the liquid since obtained have failed for some reason to produce equally good results; but the same movement is exhibited by the liquid *xylidine* 1, 3 and 4. The globules formed when one or two drops of this liquid are allowed to run on the surface of water are endowed with remarkable activity. Simultaneously, all the globules above a certain size become indented on one side only, so as to resemble a kidney in shape, when each is projected violently across the surface of the water. Some of the forms taken by the globules are shown in Fig. 7, in which it will be seen that in the process fragments are broken off the larger ones; and sometimes the indentation spreads to the opposite side and cuts the globule into two. A period of repose then follows, in which the globules all possess a circular outline; when suddenly, moved by a common impulse, all the larger globules again assume the kidney shape and dart across the surface. This continues until a number of small globules are left quietly floating on the surface; or the whole may disappear by spreading and solution. Sometimes the movements will continue, with increasing sluggishness, for an hour or more. The direction of motion across the surface is always away from the indentation, as if the globules were pushed by the force which forms the cavity.

The manner in which a film of liquid on the surface of water breaks into globules is shown in Fig. 8, and is best observed with *dimethylaniline*. When a very small drop of this liquid is allowed to trickle on to water, it spreads out into a film of irregular shape, from the thin edges of which a number of small globules immediately form. Indentations then appear round the edges, which branch out into coral-like shapes and simultaneously holes appear in the film from which similar branchings arise. The various channels unite in numerous places, thus cut-

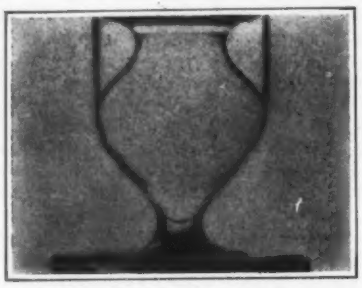


Fig. 1.—A Column of Aceto-acetic Ether in Water.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

A Column of Iso-butyl Benzoate, Stretched by Adding Water Until Breakage Occurs. Four Stages.

[1] Scientific American Supplement, No. 1945, p. 236.
* Reproduced from *Knowledge*.

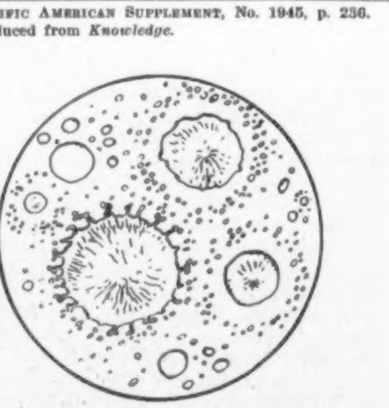


Fig. 6.—Aniline Globules Floating on a Water Surface.

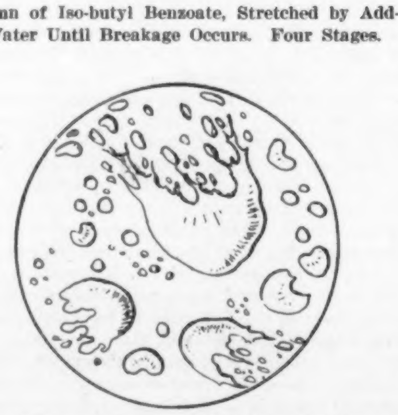


Fig. 7.—Movements of Orthotoluidine Globules on a Water Surface.

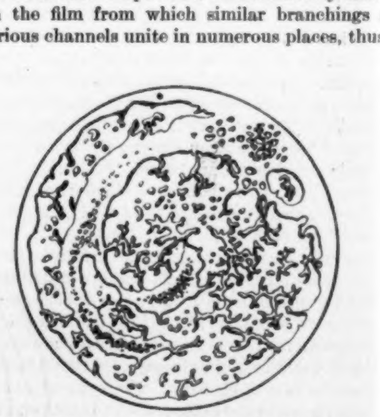


Fig. 8.—A Film of Dimethylaniline Breaking Into Globules.

ting the film up into numerous small portions, each of which immediately becomes circular in outline; and by this beautiful process a film is resolved into globules in a few seconds. In order to see this remarkable movement to advantage, an exceedingly small drop of liquid must be used, and the water must be perfectly clean tap-water. The same action can be observed with *quinoline*, in which case the division occupies a much longer time; and the globules formed, after a few minutes, become perforated in the center and remain on the surface in the form of rings, interspersed with plates containing several holes.

The surface movements described are only selected examples of a large number observed by the author; and it will be noted that the indentation of the edges of the globules or films is a common feature. There is little doubt that these indentations arise from the interplay of the tensions at work, but it is not evident why an aniline globule should be uniformly indented, while only one side of a globule of orthotoluidine is attacked. The movements introduce new features which do not appear to be capable of explanation by the usual theories of surface tension.

It may be added that the movements may be shown to great advantage by the aid of a lantern provided with a horizontal stage, vessels with a bottom of plate-glass being preferably employed. Sufficient materials for showing the phemomena a large number of times can be procured at a small cost; and when once seen it will be realized how completely inadequate any verbal description must of necessity be to convey to the mind the beauties of the movements. Hence the writer hopes that all who read will try to perform the experiments for themselves.

Radiations Old and New—I*

Corpuscular and Other Rays and Their Relation to Molecular Physics

By Prof. W. H. Bragg

The remarkable properties of the rays from radioactive substances which have been examined with such eagerness in recent years throw a curious and interesting light on the older attempts to find a satisfactory theory of radiation. Newton and Huygens, Young and Fresnel, and other thinkers down to our own times have discussed various hypotheses, rejecting, adopting, or amending, and each has given his reasons for his final choice. It is instructive at the present time to examine some of those reasons, and to consider the influences which prompted them to make their great discoveries. More particularly is this the case because some expressed their ideas in the language of a corpuscular theory, and we have now had for some time the opportunity of examining radiations which we know to be corpuscular.

Fig. 1.—α Rays from Radium. Some of the α Particles Have Traversed the Air Before the Expansion, Others After the Expansion.

Let me first of all set out some of the facts of the new radiations. Thanks to the recent beautiful experiments of Mr. C. T. R. Wilson, I am able to illustrate my statement by a method which would have been beyond my power even a few months ago. We have been for some years laboriously investigating the paths of the α, β, and γ rays through gases and other material substances. Our work has been conducted in the dark, so to speak, for we have been obliged to rely mainly on electrical methods, to feel our way along those paths in some cases, and in others to arrive at their form by indirect reasoning. Mr. Wilson has shown us how to obtain a clear photographic representation of the whole path of an α or β ray. The ocular demonstration is helpful from a scientific point of view, not only because of the confirmation which it has given of the work we have already done, but also because of its suggestiveness for the future. It is, if I may say so, invaluable from a lecturer's point of view, because it enables me to dispense with difficult explanations of the methods by which recent advances have been made, and to show direct illustrations of the points I wish to emphasize.

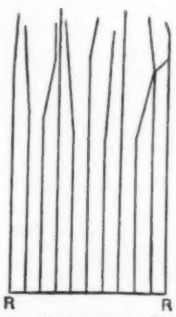


Fig. 2.—Drawing by the Author, Made Before Paths Had Been Actually Observed.

Fig. 5.—Ionization by X-ray Beam About 5 Millimeters in Diameter.

The α ray is, as is well known, an atom of helium projected by the exploding radio-active atom with a speed of some ten or twenty thousand miles a second. Although it moves off at this excessive rate it is able to penetrate only two or three inches of air in its ordinary state, or one or two thousandths of an inch of heavier substances, like aluminium or gold. When it comes to the end of its range, it has spent practically the whole of its energy, it has lost its distinction, and sinks to the level of an atom moving with ordinary speed. Some years ago I showed that it moved in an almost perfectly straight line from start to finish; and it then became evident that on its way through a gas or a metal or any other substance it passed through every atom which it met. It does not push them out of its way, for it meets hundreds of thousands of atoms, each one, as a rule, far heavier than itself; and it does not thread its way between them, for it has no intelligence, and cannot recover a line once lost. In 1907 it was shown by Mr. Geiger, working at Manchester, that the track of the α particle was not absolutely straight, but that the particle was liable to slight deflections, especially when near the end of its path.

Fig. 3.—α Rays from Radium.

Fig. 4.—A Complete α Ray from Radium Emanation.

Fig. 1 is one of Mr. Wilson's photographs of the tracks of α particles radiating from a minute speck of radium. You will see how straight they are for the most part, and yet a closer examination will show slight, very sudden, deflections.

* Evening discourse delivered on September 6th before the British Association at Dundee, and published in *Nature*.

Fig. 6.—α and β Rays from Radium.

Fig. 7.—Portions of Fig. 5 Enlarged, Showing the Individual Ions Produced Along a Portion of One of the Kathode-ray Tracks.

Fig. 8.—β Rays Produced by γ Radiation.

Fig. 3 slide is an enlargement of two tracks, one of which shows the deflections very well.

It is difficult to realize that we are looking at a picture of the path of a single atom through the air, recorded by its own efforts; and we may well ask how Mr. Wilson has managed to obtain so wonderful a result. As a matter of fact his method is an improvement on one which he had used and explained some years ago, but it will be well to describe it briefly once more. A short glass cylinder of about six inches in diameter—its outline can be seen in Fig. 1—is closed at one end by a glass plate; at the other end is a movable piston. The chamber is filled with moist air, which is chilled if the chamber is suddenly enlarged by the withdrawal of the piston. A fog is then formed, which settles in the first place on any "ions" which may be present. In the track of α and β rays there are trails of ions formed by the rays. It is only necessary therefore to illuminate the fog, and to photograph it, and we have such a picture as that shown in the illustration.

The picture confirms so far as it goes the main conclusions we had already drawn as to the path of the α ray. Fig. 2 is a copy of a drawing which I made a year or two ago to show the various forms of the path as we then pictured them to ourselves. The paths, it should be explained, are shown starting parallel from a common line instead of radiating from a point. Mr. Wilson's picture shows that I have somewhat exaggerated the deflections to which I wish to direct attention; but otherwise the agreement is satisfactory.

The results which I would emphasize are these, that an atom of helium can and does sometimes move at a rate comparable with that of light, and when endowed with that speed can penetrate other atoms with ease.

Before leaving the α ray, there is one other point I should like to mention. If we consider how it can be that deflections of the α particle are so rare, and yet so sharp, we find ourselves driven to consider with Rutherford that the deflection is due to a force exerted from a very small center or central core within the atom, backed by all the mass of the atom. It is only when the flying α particle tries to pass very close to this center that a noticeable deflection is produced. We may picture to ourselves the electrons belonging to the atom as revolving about this central core, which we must then take to be electrically positive, just as the planets move about the sun. When an α or β particle penetrates an atom and is deflected it is the central core that is in the main responsible; electron satellites are of no account. A rough analogy is to be found in the motion of a comet through the solar system.

When a deflection takes place we may expect a recoil of the atom in which it occurs. In some of the illustrations you will observe that there is a slight enlargement of the track at its beginning (Fig. 4). This may well be the recoil of the radio-active atom from which the α particle has been ejected. We have for some time been familiar with this recoil effect, which has

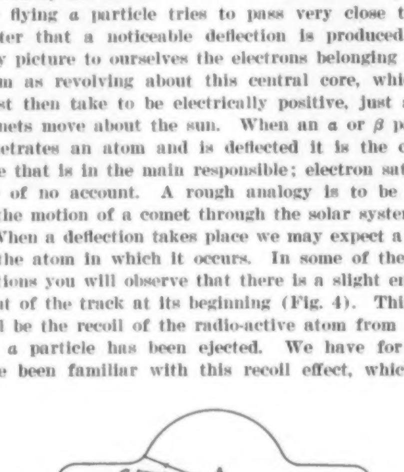


Fig. 9.—β Rays Striking Antikathode Produce X-rays.

been made the basis of certain important electrical methods of radio-active investigation. It is very interesting to see a well-marked little spur on one of the α ray tracks in Fig. 3, just where we should expect to find the effects of an atom of oxygen or nitrogen recoiling from its effort to turn the helium atom out of its path.

A β ray does not leave such an obvious track. It is the single electron moving with velocity very closely approaching in some cases to that of light. When it moves so fast it only ionizes occasionally, so that its fog track is fainter. In Figs. 6 and 8 some β ray tracks are clearly shown; some are quite straight and are due to rays of high velocity, others show much bending, and these are made by β particles which have lost their great speed, and are knocked hither and thither by collision with the atoms of the air. It is to be remembered that the β particle is many thousands of times lighter than the α particle.

Now we come to the third type of rays emitted by the radio-active substances, the γ ray, which is the same in kind as the Röntgen ray.

The fog apparatus shows no tracks which can be directly assigned to such rays. When the β and γ rays act together, only β ray tracks are found. When a stream of X-rays passes through the chamber the result is such as is shown in the figure (Fig. 5), a mass of short, tortuous tracks originating within the path of the X-rays, and ending indiscriminately inside or outside. Photographs made by weaker beams show the individual rays more clearly. The tracks are of the same character in the two cases, and the intensity only affects the number. These are tracks such as we may expect to be made by slow β rays—slow because they are very tortuous and do not go very far. Fig. 7 shows one greatly magnified, with the individual water drops deposited along the track. They are actually a few millimeters long. But the X-rays are passing in straight lines across the chamber, and you see that they leave no trace behind.

These strange results were all expected from previous investigation. It has been known for some time that X or γ rays can excite β rays in matter on which they fall; I have in recent years tried to show that the X and β rays can do nothing else. They do not themselves ionize the air or metal or other substance through which they pass; they merely bring to birth β rays which do. When X-rays fall upon a photographic plate and bring about a chemical change, or upon the animal skin and cause a "burn," as we vaguely denote the physiological effect, the X-rays have not been the direct agents, but the β rays, which spring from them. We may venture to make a guess as to how the action takes place. When an α particle passes through a molecule it may ionize more than one atom in that molecule; in the case of a very complex molecule it must often ionize several of the atoms. Such a molecule might be expected to break up or dissociate; and it is actually found that α particles do cause dissociation. Now the β particles ionizes but rarely, as the pictures show; it will be a very complex molecule in which the β particle causes ionization of two or three of the atoms of which it is constituted. Colwell and Russ have lately shown that X-rays can break down the starch molecule, a starch solution irradiated by X-rays becoming less viscous and showing the presence of dextrin. It is reasonable to expect the very large and complex starch molecule to be broken up by the β rays which the X-rays produce; and by this direct action of the β rays on large molecules we may perhaps be able to explain all the physiological actions of radium and of X-rays.

There is good evidence to show that each of the β rays, the tracks of which are seen in the illustration, is due to one X-ray and no more, and that the X-ray in forming the β ray gives it all the energy which it possesses. Further, if we consider the production of X-rays, we find that each X-ray that comes out of the bulb carries with it the energy of one, and only one, of the β rays which are hurled against the antikathode. Thus in the picture I have drawn (Fig. 9) β rays striking the antikathode A, X-rays move off, each inheriting the energy of one of the β rays. The β rays of the X-ray tube have themselves but very little power of penetrating materials; they move at only one third (or thereabouts) of the speed of the β rays of radium; but the X-ray carrying the same energy is hundreds of times as penetrating, and a large number of those which are produced at the antikathode in the bulb penetrate the glass walls. Each of these meets its fate sooner or later. In passing through some atom the reverse change takes place, and the X-ray disappears, handing over its energy to a β ray, which starts off with a velocity equal to that with which the original β ray finished when it disappeared in favor of the X-ray. It is as if the X-ray picked up the β ray, moved off in a straight line with it, and started it again somewhere else; or as if the β ray disappeared like a river going underground, only to reappear and continue its course. The β ray and the X-ray are interchangeable forms of energy-carrier. Further transformations may occur before the energy is spent. We may consider ourselves to be following the history of a small quantity of energy which is carried first by a β ray, then by an X-ray, then by a β ray again, and so on. The energy is kept intact in the X-ray form, but gradually frittered away in the β ray form, until finally it sinks to so low a value that it can no longer ionize or record its motion in a fog picture, and it is lost to view. Just as the α particle settles down to ordinary life as a helium atom at the end of its royal progress, so the moving electron, the β ray, becomes at last one of a crowd of electrons which are always on the move in matter, and are the carriers of heat and electricity. Whether it still undergoes transformations is a question we may well ask; I will consider it very briefly in a few minutes.

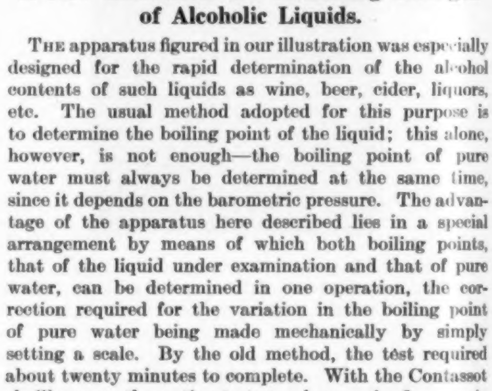
Transformation in either direction can only take place during the traverse of an atom. The atom is the transforming agent, but atoms differ in their transforming power. Usually the heavier the atom the more apt it is to bring about the transformation in an X-ray which tries to cross it, but there are regular exceptions. Every atom possesses one or more critical energy quantities; if the energy of the X-ray exceeds the critical value of the atom it is much more likely to undergo transformation than if it falls short. The critical values grow with the atomic weights, and are on the whole nearly proportional to the squares of the latter. Thus the critical energy of the zinc atom is about 1.75×10^{-8} ergs, of the nickel atom about 1.67×10^{-8} ergs. An X-ray, having an energy less than both these, is absorbed or transformed rather more readily by zinc that by nickel, but an X-ray having an energy greater than the lower but not greater than the higher (e. g. the X-ray given off by zinc when irradiated by sufficiently penetrating primary X-rays, and now known as the Zn X-ray) is actually much more readily transformed by the nickel than by the zinc.

Moreover, I believe this to be capable of extension. It is not only the X-ray that must possess energy greater than the critical value of the atom if transformation is to take place readily, but also a β ray must possess energy above the same limit if it is to be turned readily into an X-ray. Consequently a β ray is more apt to disappear if its energy exceeds the limit that if it falls short, and a stream of β rays seems actually to have less penetration than it would have if the individual rays were moving more slowly. I think I am in a position to show this as the result of recent experiment.

(To be continued.)

A New Instrument for Measuring Strength of Alcoholic Liquids.

The apparatus figured in our illustration was especially designed for the rapid determination of the alcohol contents of such liquids as wine, beer, cider, liquors, etc. The usual method adopted for this purpose is to determine the boiling point of the liquid; this alone, however, is not enough—the boiling point of pure water must always be determined at the same time, since it depends on the barometric pressure. The advantage of the apparatus here described lies in a special arrangement by means of which both boiling points, that of the liquid under examination and that of pure water, can be determined in one operation, the correction required for the variation in the boiling point of pure water being made mechanically by simply setting a scale. By the old method, the test required about twenty minutes to complete. With the Contassot ebullioscope, the entire test can be run in five or six



Contassot's Ebullioscope.

minutes. A small boiler on the left, *A*, holds the water, and the second one, *B*, the alcoholic liquid. These are both heated by a spirit lamp by means of hot-air tubes, *C*. A water-cooling tank, *L*, surrounds the escape pipes of both boilers so as to confine the vapors. Each boiler carries a thermometer which dips in it through a cover and is then bent outward so as to lie flat along a scale. On the left the scale is reduced to a simple zero mark for the water, while the second scale on the right carries degrees of alcoholic strength. Both scales are movable, but are also inter-connected and are moved inward or outward together by the milled screw head, *K*. When both liquids are boiling, the zero mark is set opposite the thermometer reading for the water, but this action also shifts the alcohol scale along to correspond, so that the alcohol thermometer will give the proper reading and show the actual alcoholic strength of the liquid.

The Birth Rate and Military Armaments*

A Problem With Which France is Wrestling

By Sidney Low

The present military crisis in Europe involves certain considerations of more permanent interest even than the perilous international rivalry with which it is immediately concerned. It brings us into contact not only with the question of European hegemony, but with the whole future of civilization and the Western races. France is about to impose upon herself a burden which none of the greater nations has yet assumed. She is preparing to drill and arm almost her entire male population of the fighting age; she will require that every one of her young citizens, with a very few exceptions, shall devote the three best years of his life to the sole and undivided occupation of learning the business of a soldier. Only in the Balkan States, and perhaps only in Bulgaria among them, has a similar sacrifice been exacted from the manhood of the country. Elsewhere universal military service is theoretically enforced; but in practice it has been far from universal. Neither Germany, Russia, Austria, nor Italy applies the principle with the same thoroughness. They do not attempt to train all or nearly all their young men in the ranks of the active army; a large proportion escape altogether, many others discharge their legal obligation by passing at once into the reserves or territorial forces. In Germany only one young man out of four has been actually submitted to the full two years' discipline of the embodied regiments. Even under the new system much less than half the contingent will be called up, and that will suffice to give Germany in peace time a standing army 900,000 strong. France, in order to obtain 750,000, is obliged to press into the ranks every young man not physically unfit to bear arms. The only exemption of importance is that allowed to the sons of large families where there are five or six children. This exemption is significant. It illustrates the real difficulty which besets French statesmen, the root cause of the danger which France is bracing herself to meet with a patriotic *elan* worthy of her gallant and chivalrous past. For the peril from beyond the frontier would be less menacing if there were not another peril more insidious at home. It is not the full German regiments but the empty French cradles which will compel 94 per cent of the young men of France to turn themselves into soldiers.

A hundred and fifteen years ago an English clergyman startled the world with one of the most famous books ever written. Malthus's *Essay on Population* was a solemn warning that civilization was in danger of dying because too many children were born. The population, he suggested, would increase so fast under the improved conditions of modern order and progress that mankind would eventually be annihilated in a squalid and savage struggle for sheer existence. Just now scarcely a month goes by without some influential person, preacher, scientist, medical expert, or statesman, giving us an admonition which is the reverse of that of Malthus. Mankind, and particularly civilized mankind, they tell us, is in the greatest danger, not because there are too many children but because there are too few. The birth-rate is falling in the more civilized countries, and within those countries themselves the fall is heaviest among the most educated and comfortable classes. The International Congress on Eugenics, held last year in London, was brought together mainly to consider what this process means and how it can be averted.

As to the decline of the birth-rate there can be no question. It has been put forward as a "law" that the rate of increase falls with the advance of civilization. It may not be a law, but it seems to be the fact. The complex, highly organized, materially prosperous, and intellectually developed communities increase more slowly than those which are simpler and more primitive. The further we get away from barbarism and want, the lower is the birth-rate. France, with a longer record of stable, highly finished culture than other European country, has a birth-rate the lowest of all—a birth-rate so low that there are now barely enough persons born to compensate for those who die. But France is only some rungs further down the ladder than the other great civilized nations, for they, too, are descending, though by slower steps. There is a tendency to retardation of the birth-rate in all the progressive and prosperous countries. It is extremely well marked in the Australasian States, where the general standard of material well-being is probably higher than anywhere else in the world. Amid the virile, comfortable, four-meals-a-day population of New South Wales, Victoria, and New Zealand, the rate has diminished by nearly half during the past thirty years. In the United States the increase of population (exclusive of immigration), which was over 35 per cent per decade in the middle of the last century, has now dropped to a little more than 20 per cent. In the United Kingdom the process is almost equally striking. In the ten years, 1861-1871, the increase by birth was 37.56 per cent. In the following decade it had risen to 37.89 per cent. In 1881-1891 it had fallen to 31.57 per cent, and the last report of the census of England and Wales shows that it had dropped further and descended to 28.56 per cent. The death-rate during the same half-century had fallen from an average of nearly 24 to 16.13, and it is owing to this diminution that the excess of births over deaths shows only a comparatively slight fall. But, as the Registrar-General points out in issuing the figures, "though the rate has been maintained during the last decennium as a result of the remarkable decline in mortality through the period, it must be pointed out that there is no present likelihood of prolonged continuance of this experience, since there is as yet no indication of any check in the decline of the birth-rate, while it is obvious that the death-rate cannot continue to decline indefinitely." In point of fact, over a large part of the United Kingdom the birth-rate is very little higher than that of France, although, owing to superior sanitation and hygienic laws, the death-rate remains at a much lower level. This is still more the case in the Australian Colonies, where, in spite of the low birth-rate, the annual excess of births over deaths is proportionately larger than that of almost any other country because of the low death-rate, which in New South Wales is less than half that of France or Germany, and less than a third that of Russia.

Two interesting questions arise in connection with these facts and figures. The first, which is of extreme moment to France just now, is that of the relative decline in the population of the great nations. If most of them give indications of the same tendency at work they are not all affected to the same extent. In Russia, though the birth-rate is falling, it still remains much higher than that of any of the Western countries, and the subjects of the Tzar continue to increase by millions every year. In Germany, with a moderately high death-rate, there is still a high birth-rate, and the annual increase remains very large. During the last few years the process has been checked, and the stagnant condition of the population in the great cities and chief industrial districts has caused considerable anxiety to German statesmen, so that the Prussian Government has appointed a commission to inquire into the whole subject, and to consider, whether any remedies can be applied to check the decline. Nevertheless, in "the competition of the cradle," Germany still does very well in comparison with its western neighbor. At the time of the Franco-German War, the population of France was very nearly equal to that of Germany, that of the former being a little over, that of the latter a little under, forty millions. During the intervening forty-two years, France has added nothing to her numbers, while Germany has put on some eight and twenty millions, so that she is now much more than half as large again as her old rival. Austria, too, Germany's ally and adjunct, has also made great advances; with the general result that France, which at the time of the Napoleonic wars and for a whole century before that, was the most populous country in Europe, except Russia, now only stands fifth on the list, having been surpassed not merely by the Muscovite millions, but by the millions of Germany, Austria, and the United Kingdom, and being now not far ahead of Italy.

It may be said, of course, that mere size and numbers are not everything. One may be quite willing to believe that forty millions of Frenchmen are of as much value to the world as four hundred millions of Chinese or a hundred and sixty million Russians, mostly pauperized peasants. For many purposes perhaps they are. Unfortunately, there is one sphere of human activity in which numbers do count. In the conflicts of nations, whether they are fought out on the military, on the diplomatic, or even the industrial battlefield, man-power is an element of prime importance. As warlike appliances tend to be standardized, and as military science and discipline are no monopoly of any one country, there is a presumption that a State which can assemble a larger number of armed and drilled men than its rival is *ipso facto* more likely to obtain success in a contest. The individual Frenchman is, no doubt, as good a man as the individual German, he may even be better; but there is no particular reason to suppose that two French soldiers, armed with the best modern weapons and trained under the best modern canons of the military art, would be equal to four Germans or Austrians similarly equipped and instructed, or even to four Russians or Chinamen. And it does nothing to abate the anxiety of French statesmen to know that fifty years or a hundred years hence their rivals and neighbors will also become stagnant. All the nations may tend to slow down, but the process goes on more rapidly with some than with others. If the whole manhood of Germany were arrayed against that of France, the armies of the Republic would be completely outnumbered, and for a good many years to come, at any rate, the disproportion is likely to grow. Naturally, this makes the French nervous. Last year M. Millerand, the French War Minister, openly admitted in the Chamber of Deputies the weakness of France in this respect, and suggested that it might be necessary to remedy it by an extensive enlistment of negro soldiers in the African territories of the Republic. Half a million black Sepoys could be recruited for the armies of France by this means; but it is not exactly a sign of strength for a civilized nation to depend for its existence on mercenary troops levied from a semi-barbarous population. The Germans themselves are alive to the danger, and their opposition to the French acquisition of Morocco was largely based on this consideration. They were not anxious to provide France with another great recruiting-ground from which she could draw warlike reinforcements for her own stationary territorial armies.

* Extract of an article published in the *Fortnightly Review*.

Fish-eating Habits of a Spider

By E. C. Chuble.

In a lecture delivered to the Natal Scientific Society on November 22nd, 1911, the Rev. N. Abraham described the habits of a spider that he had observed catching and eating fishes.

When Mr. Abraham's lecture was given the spiders had not been determined, but I have since had an opportunity of examining two preserved examples in his possession, and I have determined them as *Thalassius spenceri*, Picard-Cambridge.

The following is an extract from the newspaper account: "In the year 1905 I was living in Greytown, Natal. One day I was catching small fish and aquatic insects for an aquarium. I was using a small net in a shallow stream. I happened to see on the edge of the water a fine spider, which I captured. On reaching home I placed my specimen in a large aquarium, where I had a number of small fish. The spider measured about three inches when its legs were extended; the body is small, but the legs are long. After being on the rockwork of the aquarium for some time, it took up a very interesting position. It rested two legs on a stone, the other six rested on the water, well spread out, the ends of the six legs commanding a definite and well-defined area of water.

"Being busy, I merely took a note of its attitude, and left it to its devices. After a few minutes my servant boy came into my study to say that the spider I had put into the aquarium was eating one of my pet fish. I at once went to see what had happened, and soon saw the spider on top of the rockwork, holding in its grip a beautiful little fish about four times the weight of its captor. For a moment I was startled into a strange surprise. How could this spider, which has no power to swim, catch a lively, quick-swimming fish? I looked at it in wonder, as it seemed to clutch the fish as a cat clutches a mouse. It soon began to devour its catch, and after some time had passed nothing was left of the fish but its backbone. The spider had eaten it as surely as an otter eats its trout.

"I was now anxious to find out how the spider caught the fish. That night, about 11 o'clock, when I had finished my day's work, I sat down by the aquarium to watch the spider, with the hope that I might see how the fisherman caught his fish. The spider had taken up a position on a piece of stone, where the water was not deep, and had thrown out its long legs over the water, upon which their extremities rested, making little depressions on the surface, but not breaking the 'water skin.' The tarsi of two posterior legs firmly held on to a piece of rock just about water-level, the whole of the body was well over the water, the head being in about the center of the cordon of legs, and very near to the surface of the water.

"After watching for some little time, I saw a small fish swim toward the stone and pass under the outstretched legs of the spider. The spider made a swift and sudden plunge. Its long legs, head, and body went entirely under the water, the legs were thrown round the body with wonderful rapidity, and in a moment the powerful fangs were piercing the body of the fish. The spider at once brought its catch to the rocks, and began without delay to eat it. Slowly, but surely, the fish began to disappear, and after the lapse of some time the repast was over.—*Nature*.

Samples of the Best Grade.

The Commercial Importance of Cork Bark

By A. J. Clansay

The Lowest Grade of Cork.

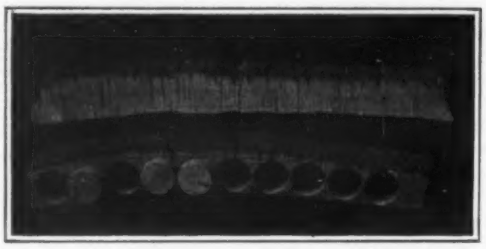
The bark of the cork oak (*Quercus suber*) is an important article of commerce, our imports of crude and manufactured cork amounting in value to considerably over four million dollars annually. The demand for and consumption of cork in the United States has increased since the year 1891 over nine hundred per cent and is still far beyond the actual means of supply. The value of imports of cork bark including cork bark cut into squares or cubes and corks three fourths of an inch or less in diameter in 1911 amounted to $4,274,810, practically all of which is used here. Its price varies, according to quality, and fluctuates considerably from year to year. The Spanish cork brings the highest price. Of ready-made corks the imports have been steadily on the increase, and all of those imported are used here. The average price is a little over 30 cents per pound.

The total value of imports of cork bark in the United States for each year from 1901 to 1911 is as follows:

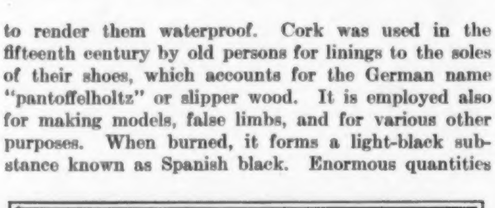
Year.	Value.
1901	$1,729,912
1902	1,816,107
1903	1,737,366
1904	1,484,405
1905	1,729,143
1906	1,837,134
1907	2,356,052
1908	2,092,732
1909	2,016,551
1910	3,152,280
1911	4,274,810

The cork-producing territory of the world covers practically the whole of Portugal and extends eastward through the southern districts of Spain known as Andalusia and Estremadura, and from there northward to include thousands of acres in Catalonia. It attains to the greatest perfection in Portugal, to which country we are indebted for the major part of our supply. Algeria, with Tunis, ranks next in importance in bark production, followed closely by southern France, including Corsica. In France it is found in great abundance in Languedoc, Provence, the environs of Bordeaux, and the department of Var. Italy, Sardinia, Sicily and Morocco also contribute a share. The total area covered by cork forests is estimated at about four and one quarter million acres, producing annually about 50,000 tons. A large proportion of this is exported to the United States. The countries from which cork bark is consigned are France, French Africa, Germany, Gibraltar, Italy, Portugal, Spain and England.

Cork is light and porous, readily compressible, and remarkably elastic. These qualities make it superior to all other substances for stoppers for bottles, in the manufacture of which it is principally made use of. It is used extensively as buoys to seine and gill nets, the construction of life-boats, cork jackets, cork belts, and other life-preservers, and cork mattresses. An ingenious application of cork is made for lining the uppers as well as the soles of shoes and boots in order to render them waterproof. Cork was used in the fifteenth century by old persons for linings to the soles of their shoes, which accounts for the German name "pantoffelholtz" or slipper wood. It is employed also for making models, false limbs, and for various other purposes. When burned, it forms a light-black substance known as Spanish black. Enormous quantities of the best grade of cork bark are used at present for making cigarette tips. For this purpose very thin sections from 200 to 300 plates to the inch are cut by machinery. The waste obtained in the manufacture of these numerous articles is used in making composition cork, which is employed for the same purposes as the original. This waste is also employed in stuffing cushions, in packing eggs and other fragile articles, and in making cork floor tiling. Cork flour mixed with melted India rubber forms one of the chief constituents of linoleum. Granulated cork is also widely used for heat insulating purposes, often in the form of cork board made up either with or without an asphaltic binder. The low conductivity and great durability make cork almost ideal for insulating cold storage and refrigerator rooms.



Strips of Bark from Which Corks are Punched.



Cork Bark Sliced Into Strips.

The word *cork* is said to be derived from the Spanish, *corcho*, which comes from the Latin word *cortex*, meaning bark. Cork bark is composed of soft cellular tissues (parenchymatous) and of a small portion of hard woody tissue. In good cork the former is the most abundant, which accounts for its elasticity and facility with which it can be easily cut in all directions. When cork bark is first developed it is far less elastic than it becomes subsequently, which is due to the constantly decreasing amount of woody tissue as the tree becomes older. The first crop of cork bark, or virgin cork, as the first stripping of bark is called, is so rough, coarse and dense in texture that it is practically useless. This outer bark of the cork tree is now very much used for window flower boxes, grottoes, etc. If the virgin cork is properly removed further development of commercial cork takes place and after eight or ten years is thick enough to be cut. Subsequent strippings follow at regular intervals of about nine years. The parenchymatous substance will go on growing as long as the bark is alive, a provision of nature connected with the annual increase in diameter of wood, and the necessity of the bark giving way to the pressure from within. If the growth of the parenchyma is prolonged and rapid, a corky substance is the necessary consequence, as in the cork elm, the alpine fir, and a number of other trees; but it does not occur in any American tree in such abundance as in the cork bark.

The careful removal of this outer or dead bark does not in any way injure the tree; on the contrary, it is said to grow more rapidly and live longer as a result of removing the bark. After a tree has attained to the age of 25 or 30 years, it may be barked, and the operation can be subsequently repeated every eight or ten years, the quality of the cork improving with the age of the tree. The bark is stripped from the trees in July and August, and if they are regularly barked they are said to live for 150 years. The bark is stripped from the tree in pieces of about two inches in thickness, and as long as it can be conveniently obtained. The peelers make a perpendicular slit in the bark with a sharp knife. A second incision is made parallel to it

In the Blocking Department, Where the Corks are Bored Out.

Sorting Department for Tapered Corks.

Putting Final Touches on Life Preservers.

and at some distance from the former. Two shorter horizontal cuts are made, one at the top and one at the bottom. Sometimes after these cuts are made the tree is left for a time so that the moisture from the sap may dry. For removing the pieces thus isolated, a knife with a curved blade and two handles is used. The detached pieces of cork are then soaked in water, and are placed over a fire when nearly dry; in fact, they are scorched a little on both sides, which renders them more compact and gives the material what the cork cutters call nerve. This charring has also the effect of closing the cells on the outside of the cork, which otherwise would absorb moisture and render it useless for a good many purposes. After this they are pressed down with weights while yet hot in order to get rid of the curvature. The charring occasions that peculiar and disagreeable flavor which is sometimes imparted to liquids which have been stopped by slightly scorched corks.

The United States Patent Office as early as 1858 secured some cork oak acorns from southern Spain and distributed them to those sections of the country where it was thought they would grow. A report made at the close of 1875 showed that the acorns planted in 1859 came up and that several trees were flourishing at different points throughout South Carolina. This showed that the conditions in the Southern States were well adapted for growing the cork oak on a commercial scale. In 1862 a similar successful test was made in California. An acorn of the cork oak planted in 1862 at Santa Barbara, California, sprouted and the young tree made a height growth of 20 feet in 15 years and developed a bark of an inch and one half and the cork apparently of the best quality. In the latter part of the '80's, 5,000 more acorns were distributed by the Division of Forestry to people in the South Atlantic and Gulf Coast States and also to a few growers in Arizona and California. There are now quite a number of cork oak trees of considerable size growing in this country. Within the last year the United States Forest Service has planted cork oak on a considerable area on the Choctawhatchee division of the Florida National Forest. The object is to treat these trees so as to enable them to form layers of commercial bark. Such experiments, although somewhat limited, are much needed to demonstrate what quality of cork the trees in this country will ultimately produce.

Evolution from the Standpoint of Physics—I*

The Principle of the Persistence of Stable Forms

By Alfred J. Lotka, M.A., D.Sc.

There is a widespread and no doubt justified impression, that the process of evolution tends to follow some definite direction. When, however, we attempt to state what the character of this trend is, we meet with difficulties. Thus it is sometimes asserted that evolution tends toward the development of "higher forms." This phrase is in itself altogether too vague to be of much scientific value. Our judgment of what constitutes a "higher form" would seem to be largely dependent on our æsthetic sense and obviously gives every opportunity for divergence of opinions.

If, on the other hand, we define a "higher form" as a "more complex form," or perhaps as a "more highly specialized form," then we certainly cannot assert that in all cases evolution tends toward the development of "higher forms."

Looking at the matter from a slightly different point of view, we may say that the *principle of the survival of the fittest* is in one sense a truism, inasmuch as we define the fittest as that which survives.[1] But we may ask: What are the general characteristics, if any, by virtue of which it survives?

The problem gains greatly in precision if we examine it from the standpoint of physics and in its quantitative aspect.

While we are not in a position to state that evolution is a purely physical phenomenon (inasmuch as it involves the influence of such agencies as life and consciousness, regarding the nature of which there is at the present day no definite information), we can say positively and without introducing any element of controversy, that evolution is *attended* by physical changes. These changes form a legitimate subject for physical investigation, and in this sense, at the least, evolution appears as a problem of physics. The fact that possibly ultra-physical agencies are involved need not necessarily deter us from attacking this problem. For we are familiar from the study of thermodynamics and certain branches of mechanics that it is quite possible to form very accurate and valuable conclusions with regard to certain initial and final states of a given system without knowing anything regarding the mechanism or path—i. e., regarding the intermediate states—through which the system passes in changing from its initial to its final state. And that the intervention of life and consciousness has at most only a restricted influence over the course of physical events, is at the present day well understood. The observations relating to this matter may be briefly summed up in the statement that the function of life and consciousness in mechanics is directive.[2] We can, as intelligent living beings, direct the course of the energy flux, and perhaps stem it, but we can never, by any means within our power, reverse it.

And again, if the application of physical principles to the discussion of systems comprising living matter has its limitations, this is no reason why we should not make every effort to extend the scope of physical inquiry to the utmost limits attainable, but rather, on the contrary, is it an incentive for us to press forward and discover the character and extent of such limitations if they exist.

From the point of view of physics, then, we may concisely state the problem of evolution as follows:

Given a material system in some specified state, A, the question arises whether it is possible for that system, under specified conditions, to pass into another specified state, B.

Conversely, if it be known that a material system undergoes, under specified conditions, a change from a specified state A to other specified successive states B, C, D, . . . the question arises, what are the characteristics of the states A, B, C, D, . . . by virtue of which it is possible for the successive changes to take place?

The problem thus stated is of exceedingly general scope, and our hope of accomplishing anything toward its solution must lie in the treatment of such special cases as may be of interest and amenable to investigation. Nevertheless, there are some observations of quite general scope which should be noted at this point.

Quite generally it can be said that the possibility of a given change A-B depends on the fulfillment of two classes of conditions:

1. Conditions relating to the character of the state A and the state B.

2. Conditions relating to the character of the available paths from the state A to the state B.

The following simple example taken from mechanics may illustrate this point:

A ball at rest in position A, and subjected solely to the action of gravity and to the reaction of a supporting surface, can move from position A to another position B, provided:

1. That position A is at a higher level than B.

2. That a path is available from A to B, no point of which lies vertically higher than A.

The two groups of conditions thus defined lead to a classification of all possible states of a material system under three types:

(*a*) If for a given state A, and every possible other state B, neither conditions (1) nor conditions (2) for the change A-B are satisfied, then the system will remain in state A indefinitely, so long as these circumstances obtain. The system is then said to be "*stable*" in state A.

(*b*) If for a given state A there are one or more states B, such that conditions (1) for the change A-B are fulfilled, but none which satisfy both conditions (1) and (2) for the change A-B, then the system will also remain indefinitely in state A so long as these circumstances persist; but a change A-B will begin to take place as soon as, other things remaining the same, conditions (2) are fulfilled.

In this case (*b*) the system is said to be "*metastable*" in the state A.

(*c*) If for a given state A there are one or more states B, for which both conditions (1) and (2) are satisfied, then the change A-B will be actually taking place. The state A is in such case therefore transitional, labile, or "*unstable*."

This further leads to the following basis of comparison of two states A and B.

If conditions (1) are satisfied for the change A-B, state A is either metastable or unstable. But in any case we may speak of B as "*more stable*" than A under the given conditions.

With our terms thus defined we may now enunciate the following principle:

The course of an evolving material system is such that

* Translated and revised for the Scientific American Supplement by the author from the *Annalen der Naturphilosophie*.

[1] Compare W. Ostwald, *Vorlesungen über Naturphilosophie*, 1902, pp. 334, 337; also Doelter, *Aus dem Grenzgebiet des Organischen und Anorganischen*, 1906, p. 14.

[2] Compare O. Lodge, *Nature*, vol. 67, p. 595; vol. 68, p. 31. Also the same author's book, "Life and Matter."

the system passes successively from states less stable to states more stable under the existing conditions.[3]

Let us see how the principles just considered apply to a simple system capable of supporting life:

To make the case concrete we may think of a sterilized bacterial culture-medium contained, say, in a vessel and protected from infection by suitable means. This is our system in the state *A*, specified by statement of the values of suitably chosen variables, temperature, pressure, volume, composition, etc.

We know that there is another possible state for this system, a state *B*, in which it consists in part of unaltered culture-medium and in part of living matter. Is it possible for our system, under the specified conditions and without external intervention, to pass from state *A* to state *B*?

We know that here the conditions of the first type for the possibility of the change *A-B* are satisfied, for under the right conditions the system does pass from state *A* to state *B* by the growth of living matter in the medium. But, so far as is known to the science of to-day, the conditions of the second type cannot be satisfied in the absence of a "germ" of living matter: the system is metastable.

Inoculate the medium with such a germ, however, and immediately the change *A-B* is initiated.[4]

What is more, in general the change does not end merely with the production of living matter: If the system is placed under suitable conditions, a series of further changes, *B-C-D* . . . occur, involving the modification of living forms as generation follows generation, and representing what we are accustomed to speak of as *organic evolution.*

And just as the first beginning of life within the system was in accordance with the physical principles enunciated and exemplified above, so, step by step, the successive states *C*, *D*, . . . through which the system passes in the course of evolution, must accord with these principles.

* * * * *

So much then for a broad qualitative statement of some of the general physical principles involved. We next turn our attention to the quantitative aspect of the problem.

To express quantitatively the material changes which constitute or at any rate accompany the evolution of a given system, we may divide that system in any suitable manner into specified components.

The state of the system at any instant is then defined by statement of the quantity (mass) M and state S of each component, while a statement of the changes in M and S for the several components defines the corresponding changes in the state of the system.

In particular, if the mode of specifying the several components of the system is such that it fully defines the state of each component as well as its quantity, then the state of the system is fully defined by statement simply of the quantity (mass) of each component so specified.

The material changes of a system in evolution may, then, always be regarded as a change in the distribution of matter among specified components of the system.[5]

Now every such change in the distribution of matter in a given system is accompanied by some definite energy change (which as a special case may have the value zero). As soon as we know the relation which connects the several material changes with the concomitant energy changes, we are in a position to apply the general laws governing energy changes to the case of an evoluting system.

This method has been successfully applied to the study of the laws of change of state—whether by physical or chemical transformation. We need only recall the thermodynamic development of the Calpeyron-Clausius latent heat relation, of the law of mass action, of the law of Le Chatelier and van't Hoff, etc. That these cases of a system in physical or chemical transformation represent special examples of evolution need hardly be emphasized.[6] For our attitude toward the problems of evolution from the point of view of physics, as set forth above, may be summarized in the following definition and proposition:

The evolution of a given material system is a process which may be expressed as the progressive change in the distribution of matter among specified components of the said material system, through a series of steps taking place in accordance with the principle of the persistence of stable forms (survival of the fittest).

Every change in the distribution of matter in a given system, under given conditions, is accompanied by a definite energy change. Therefore the laws which govern energy changes are laws governing evolution.

This definition and this proposition furnish us with a precise formulation of the physical problem of evolution, and with a general method of investigation to use in our efforts to solve that problem.

It is interesting to compare with our position, thus defined, the oft-quoted words of Spencer ("First Principles"):

" . . . we have to contemplate the matter of an evolving aggregate as undergoing not progressive integration simply, but simultaneously undergoing various secondary redistributions; we have also to contemplate the motion of an evolving aggregate, not only as being gradually dissipated, but as passing through many secondary redistributions on the way toward dissipation."

Again:

"Our formula therefore finally stands thus: *Evolution is an integration of matter and concomitant dissipation of motion; during which the matter passes from an indefinite, incoherent homogeneity to a definite coherent heterogeneity; and during which the retained motion undergoes a parallel transformation.*"

It will be seen at once that Spencer's formula is in accord with the definition and proposition stated above. But his formula is more than a definition; it is a statement of what to Spencer appeared to be the characteristics of evolution. It is not a definition, but a description; not the setting of a problem, but Spencer's answer to the problem.

(*To be continued.*)

[3] Compare Le Dantec, "La Stabilité de la Vie," p. 26. The physical principle here enunciated is evidently closely related to the principle of the survival of the fittest, or, as we may express it in more general terms, the principle of the persistence of stable forms.

[4] The germ plays the part of a "catalyzer," in accordance with our observation above, that the function of life in mechanics is purely directive. It is very instructive to consider here a case which presents a close analogy to that of the "culture medium" discussed above, namely, the case of a supersaturated vapor or solution. Such a vapor is "metastable" in its state *A*, but can be made to pass into the state *B*, i. e., the state of partial condensation (into liquid or solid) by the introduction of a suitable "germ" or "nucleus" such as a drop of the liquid or a crystal of the solid. Here, as in the culture medium, the product itself of the change *A-B* is the catalyzer; we have, in other words, a case of *autocatalysis*. There is this difference, however, between the two cases, that in the case of purely physical change of state we have other means, aside from the introduction of "germs," for starting the change *A-B*. In the case of the culture medium we know of no such means, and it still remains true, therefore, to the present day, so far as we know, that "*omne vivum ex vivo.*" The case of the supersaturated vapor is particularly instructive in that here it is possible to state conditions (1) and (2) in clear-cut and perfectly definite terms: If the system is kept at constant temperature and at constant volume these conditions take the following form: In order that the change *A-B* may be capable of taking place spontaneously, it is necessary: 1. That the *free energy* of the system in the state *A* be greater than in the state *B*. 2. That there be a path for the change *A-B*, such that during this change the free energy of the system diminishes continually.

[5] Compare F. B. Jevons, "Evolution," Macmillan, 1902, Chapter VI, p. 72; "Evolution as the Redistribution of Matter and Motion."

[6] Compare Perrin, "Traité de Chimie Physique," p. 141.

Electricity Direct from Coal*

The Problem of the Galvanic Cell With Carbon Consumption

By Prof. Emil Baur

[*Except in localities where water-power is available, coal is the main source from which we to-day derive our electrical power. Unfortunately, in the process of converting the potential energy of the coal into available electrical energy, a series of heavy losses is incurred. There is firstly a loss of heat by the stack, heat which should have gone into the boiler; secondly, power is lost through the fact that a heat engine at the best can transform into useful work only a definite fraction of the heat supplied; thirdly, we have the losses due to friction in the engine, dynamo and electro-motor; and fourthly, electrical losses in the dynamo, transformers, transmission line, and electro motor.*

All these losses, except those in the line and the motor, could be avoided if we could construct an efficient galvanic cell in which carbon is consumed instead of one or other of the costly materials employed in the galvanic cells now in use for work on a comparatively small scale. The problem of constructing a carbon cell is therefore one of peculiar interest and one which remains to this day unsolved. That some important steps toward its solution have been taken will be seen from a translation which is presented here from an article in the German periodical Prometheus.—Ed.]

The galvanic cells in common use are based on the use of a readily oxidable metal and a readily reducible metal oxide. Thus for example the lead storage battery makes use of lead and lead peroxide, the Edison accumulator has electrodes consisting of iron and nickel peroxide, while the so-called cupron cell is fitted with a zinc and a copper oxide electrode. The chemical action which takes place when the circuit is closed consists in each case in a migration of oxygen from the oxide through the electrolyte to the metal, which is oxidized thereby.

Such cells are a very costly source of electrical energy. Per unit of the energy which they can furnish, the metals, even iron, are very expensive, and the oxides, as prepared in the chemical industry, are even more costly.

The question therefore arises whether it is not possible to find reducing and oxidizing agents which should be equally efficient in galvanic cells, but which should be free from the economic defects inherent in the materials hitherto employed.

A hint as to the direction in which we must look for a solution of our problem is given us by the cupron cell. After the copper oxide of this cell has been reduced to copper it is regenerated by simply heating it in the air and can then be used over again. In this case, therefore, the substance consumed is atmospheric oxygen, which costs nothing. The ideal cathode, in fact, would be an oxygen electrode.

As regards the cheapest anode, it must be remarked that in a sense all oxidations are cases of combustion, so that the best material for the anode would be some cheap combustible, in particular, coal. Our problem therefore finally reduces itself to that of constructing a cell of the type,

$$\mathrm{C}|\text{electrolyte}|\mathrm{O_2}.$$

When the current is flowing, the oxygen in such a cell should migrate through the electrolyte to the carbon, oxidizing it to carbon dioxide.

Before we proceed to discuss how this problem is to be solved, let us first of all consider whether the thing is really worth while. Unquestioned experimental difficulties there are. To conquer these is always a matter of scientific interest. But is there anything to be gained commercially?

Now, for instance, it might be urged that the production of electricity from coal is a matter of every-day practice anyway, so that the scheme proposed seems to lack novelty, and it is not obvious what would be gained thereby. For we burn coal under the boiler, the steam drives a dynamo, and thus we have electricity from coal.

Yes, but remember what thermodynamics teaches us: If the combustion of the coal furnishes a quantity of heat Q according to the equation:

$$\mathrm{C+O_2=CO_2}+Q \text{ calories} \qquad (1)$$

then, *at the very best*, the amount of work derivable from our steam engine will be:

$$W=Q\,\frac{T_1-T_2}{T_1} \qquad (2)$$

where T_1 is the absolute temperature of the boiler and T_2 that of the condenser.

On the other hand, the same laws of thermodynamics, applied to a galvanic cell, tell us that from the same heat of reaction Q we can, in such a cell, obtain an amount of energy available for conversion into work,

$$W=Q-T\times\text{constant} \qquad (3)$$

The constant which occurs in this equation depends on the character of the cell and is in most cases small, in the case of the carbon cell altogether negligible, so that here we have practically,

$$W=Q.$$

In other words, practically the whole of the heat of combustion in such a cell is directly convertible into electrical energy, while in the case of a steam engine the fraction $\frac{T_1-T_2}{T_1}$ is at the very utmost, in round numbers, one half.[1]

In order to ascertain the value of Q and the constant which appears in equation (3) it is not necessary to actually construct the reversible carbon cell. Thermodynamical considerations enable us to determine these values from chemical equilibrium constants. Thus, long before a reversible carbon cell was in existence, its electromotive force had been exactly determined, and the problem of

* Translated for the Scientific American Supplement from *Prometheus.*

[1] It should be remarked that both in the case of the heat engine and the galvanic cell the action must be "reversible" if the formulæ given above are to apply. That is to say, on reversing the current through the cell, all actions within it must be exactly reversed.

constructing the cell could therefore be attacked with full knowledge of the possibilities involved. The known heat of combustion Q of carbon gives for the electric motor force of the cell just about 1 volt, the same value as in the Daniell's cell.

As it is found that the reversible carbon cell should give very nearly a 100 per cent energy efficiency, the plan of constructing this cell appears very inviting.

The first problem which requires solution is to find an oxygen electrode from which this element is capable of entering into electrolytic solution. For aqueous solution such electrodes have long been known. They were first indicated in 1854 by Grove, who employed them in his oxyhydrogen secondary cell. The use of platinium electrodes for the electrolysis of water is a matter of common practice, and Grove showed that this cell can be made to work in the reverse direction, as a secondary cell yielding current, if the electrodes were coated with platinum black.

It is true that more recently it has been shown that the platinium-oxygen electrode is not truly reversible, owing to the formation of platinum oxide, entailing a loss of 0.2 volt. This in itself might not be such a serious matter. More troublesome is the fact that such electrodes, while they furnish an electromotive force, give very little current owing to polarization. We must therefore look about for some better means for our purpose.

Carbon itself seems at first sight rather hopeless. At ordinary temperatures it is practically unassailable chemically and electrochemically. This is clearly brought out by the use of a carbon electrode in the Bunsen cell, where it is purposely employed as remaining unattacked in an electrolyte of fuming nitric acid—one of the strongest oxidizing agents known.

The only hope with carbon therefore would seem to lie in abandoning the use of an aqueous electrolyte and resorting to higher temperatures at which all reactions proceed with greater speed and vigor. And in point of fact this line of work has been taken up with some success, as we shall see presently. Before we go on to consider this we may, however, briefly note in passing that there is another possible way out of our difficulties.

We might, instead of carbon, use some such substance as wood or paper, carbohydrates which would give about the same results as carbon itself. And this can actually be accomplished—with a certain limited degree of success.

If one of the orange-red salts of cerium is dissolved in potassium carbonate, a yellow solution is obtained. If grape sugar is added to this solution, its color is gradually discharged, the cerium salt being gradually reduced, while the sugar becomes oxidized to carbon dioxide. If the solution is now shaken up with air it turns yellow again. This alternation of changes can be repeated until all the sugar is used up. What happens in this case is that the sugar is oxidized by the air, much as in the animal body, at ordinary temperatures.

A voltaic cell may be based upon this action, as shown in Fig. 1, in which d represents a porcelain diaphragm; a is the anolyte, consisting in a cerous salt dissolved in a solution of potassium carbonate, to which has been added sugar, paper pulp, sawdust or the like. The catholyte consists of a ceric salt dissolved in potassium carbonate and traversed by a stream of air introduced through the tube r. The electrodes n_1 and n_2 are made of nickel. The cell is preferably set in a water bath and kept at 70 to 80 deg. Cent. to increase the reaction velocity. The reaction on closed circuit consists in oxidation by the air of the cerous salt formed at the cathode, and reduction by the carbohydrate of the ceric salt formed at the anode.

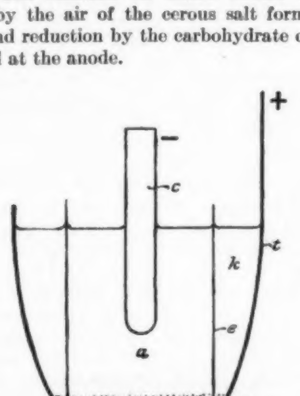


Fig. 2.—The Jacques Cell, Which Produces Electricity From Coal and Atmospheric Oxygen at 300 Deg. Cent.

A feature of special interest about this cell is its analogy to the physiological action of the muscles and their relation to respiration. At the catholyte we have oxygen taken up, as in aspiration by the lungs. The cerous salt fulfills a function precisely analogous to the hemoglobin of the blood. At the anolyte we have expiration. The ceric salt here corresponds to the glycolytic ferment of the body. The current derived from the apparatus is the equivalent of the work performed by the muscle, work derived, as is well known, from the oxidation of glucose, just as in the electrolytic cell here described.

Cells thus constructed give an electromotive force of

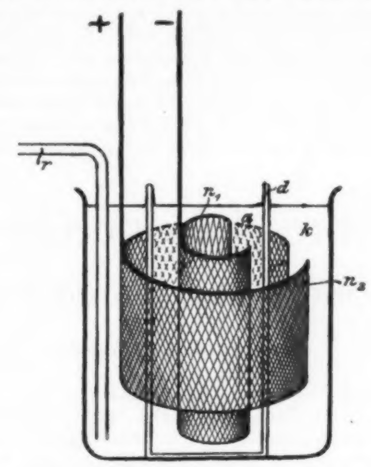


Fig. 1.—Baur and Glaessner's Cell, Which Produces Electrical Energy by the Oxidation of Sugar by Atmospheric Air in the Presence of a Cerium Salt.

0.6 volt, which is not to be despised. The balance of 0.4 volt, which should be obtainable, according to theory, in a reversible cell, is lost by irreversible changes at the ceric electrode. But a more serious defect is the fact that the cell is rather badly polarizable. Even small quantities of the ceric salt at the anode and cerous salt at the cathode impair the electromotive force. If the voltage is to be kept up, the reaction velocity would have to be increased considerably beyond that indicated.

But with all its shortcomings the cell described points a useful lesson for the construction of the carbon cell functioning at comparatively high temperature. The path thus indicated has been followed not without success. The first carbon cell to which our considerations naturally lead us is the Jaques cell, illustrated in Fig. 2. In this drawing t is an iron crucible which serves at the same time as positive electrode. It is heated to about 300 deg. Cent. and filled with fused caustic soda; the bottom is covered with a layer d of granulated quicklime which acts as diaphragm, as a sheet-iron cylinder is set with its serrated lower edge resting upon this layer. This cylinder divides the contents of the crucible into a cathode chamber k and an anode chamber a. Into this latter depends a carbon rod c, while in the cathode chamber a quantity of manganese dioxide is added to the caustic soda. The dioxide dissolves in the fused alkali and takes up oxygen from the air, forming a green melt containing sodium manganate and having approximately the same potential as oxygen. On closing the circuit the manganate becomes reduced to manganite, which in turn is reoxidized by the air, functioning in much the same manner as the cerous salt in the cell described above. The carbon reacts with the caustic soda with formation of sodium carbonate and hydrogen, and it is really this latter which furnishes the electromotive force, so that, to be precise, this cell is not a carbon cell, but an oxyhydrogen cell. And in point of fact the voltage is approximately that corresponding to oxygen and hydrogen electrodes.

Inasmuch as the carbon is burnt to sodium carbonate, and not simply to carbon dioxide, the Jaques cell is not strictly speaking a solution of the problem before us. But such a solution can be found, by the use of a somewhat similar course of intermediate reactions, if, instead of working in alkaline solution, we employ an acid electrolyte.

This can be accomplished as follows: A porcelain beaker containing a clay diaphragm is charged with pure sulphuric acid. On the one side of the diaphragm a solution of vanadium pentoxide is added to the electrolyte, and a current of air is kept circulating through. The electrode is a gold-plated carbon rod. On the other side of the diaphragm a carbon electrode and any suitable combustible are introduced. The cell is heated to about 250 deg. Cent. The combustible employed may be coal, peat, wood, mineral oil, illuminating gas, or any kind of organic refuse. It reduces the sulphuric acid to sulphur dioxide, and this is reconverted into sulphuric acid by the air in the presence of the vanadium pentoxide, which functions like the manganate in the preceding example. The processes which go on in the cell may be described as those of an electrochemical sulphuric acid factory. The cell has an electromotive force of 0.6 volt, or 60 per cent of the theoretical 1 volt for the reversible carbon cell. The balance is lost in irreversible effects in the reaction of the sulphuric acid upon the combustibles fed to the cell. This cell has the very material advantage that it permits the use of the most ordinary and low-grade fuel material. In fact, it can be used for recovering values from refuse.

But the most ideal process, in other respects, becomes useless if the plant required occupies too much space. Unfortunately, this difficulty would be very apt to arise here, for the cell cannot furnish much current without suffering considerable polarization, a condition which can be combated only by increasing the electrode area, and thus the size of the plant.

Thus it becomes necessary to use still higher temperatures. Only at bright red heat, where carbon burns vigorously in the air, can we hope to avoid wasteful secondary reactions, and to thus obtain a cell practically free from polarization defects over wide ranges of working conditions. The difficulty which now presents itself is to find a suitable oxygen electrode.

Looking around for an appropriate material, we finally hit upon molten silver. The silver refiner is well acquainted with the so-called "spitting" of silver. When the molten metal is allowed to cool at the surface, so as to form a semi-solid crust, little craters are formed upon this crust, which present the appearance of a boiling mass.

This effect is due to the liberation of oxygen, which is dissolved in the molten silver and which is liberated as the metal cools. One cubic inch of silver dissolves, in the molten state, ten cubic inches of oxygen, measured at ordinary temperature. Such a mass of molten silver saturated with oxygen should form a very effective oxygen electrode, capable of furnishing a considerable current, in view of the high diffusion velocities prevailing at red heat.

Experiment has, in fact, confirmed this expectation. All that is necessary is to combine such an electrode with a fused electrolyte and a carbon electrode, and we obtain a cell whose electromotive force is practically that calculated from thermodynamic data—a cell, furthermore, which shows very little polarization when properly handled.

The construction of such a cell is shown in Fig. 3. When working this cell must of course be placed in a suitable furnace. A carbon electrode C, which is formed into an inverted bell to present a large surface, hangs down into a porcelain crucible P, whose bottom is covered with silver Ag. Into this dips a porcelain tube O, through which air or oxygen is introduced. A stout nickel wire (not shown in the drawing) forms the second electrode. The space between the carbon and silver is occupied by the fused electrolyte E. In order to prevent particles of coal from falling into the silver it is well to provide a magnesia diaphragm M, as shown in Fig. 3. The electrolyte must be an oxy-salt which is fixed at 1,000 deg. Cent., which does not decompose at this temperature, is unattacked by silver and oxygen, and is also unattacked by carbon, or at least not sufficiently attacked to cause any inconvenience.

Fortunately there are a number of salts which satisfy these requirements, and which present the further advantage of cheapness. Molten glass is one such substance, also borax, potassium and sodium carbonate, or cryolite and alumina. Theory demands that the electromotive force of the carbon-oxygen cell must be independent of the nature of the electrolyte, and this is indeed found to be very nearly true; the electromotive force is in all cases close to 1 volt, as shown in the following tabulated results of experiment:

Electrolyte.	Electromotive Force.
Potassium-sodium Carbonate	0.95 volts
Cryolite and alumina	0.96 "
$K_2SiO_3+Na_2SiO_3+KF$	1.11 "
Borax	1.00 "
K_2SiO_3+KF	1.00 "

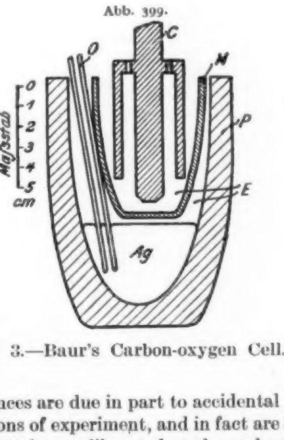


Fig. 3.—Baur's Carbon-oxygen Cell.

The differences are due in part to accidental variations in the conditions of experiment, and in fact are ascribable to the fact that the gas liberated at the carbon electrode is not pure carbon dioxide, but contains more or less carbon monoxide—in some cases as much as 99 per cent. The presence of carbon monoxide is attended by an in-

crease in the electromotive force of the cell, in fact calculation gives the following figures:

	Electromotive Force.
For pure carbon dioxide	0.997 volts
For 99 per cent CO, 1 per cent CO_2	1.129 "

The values found should lie between these two extremes, as, in fact, they do.

The problem of constructing a reversible carbon cell is therefore solved.

An important circumstance, from the technical point of view, is the fact that the cell is capable of furnishing a very considerable current without losing appreciably in its electromotive force, and furthermore, the internal resistance of the cell is relatively small. We found no observable polarization with a current density of 100 amperes per square meter.

The prospects of a commercial exploitation of the carbon cell are therefore good. The principal question that now faces us, is whether the shaped coke electrodes can be made sufficiently cheaply. If the ton of coke costs \$5 (German prices), and the carbon is burnt to CO in the cell, furnishing an electromotive force of 1 volt, the kilowatt hour costs 1.25 cents. But the electrodes used at the present day in carbide and electrochemical steel furnaces cost \$45 to \$50 per ton (German prices). With these it would not be possible to work economically.

The carbon monoxide we cannot look upon as a by-product, for at least a part of it would be consumed in heating up the cells.

The price of silver might at first be thought prohibitive. But it is not impossible that by economical use of the metal the investment of a large amount of capital might be avoided.

As regards the recovery of waste heat and the durability of the vessels employed, modern glass industry is quite able to take care of this. Lastly, a number of minor difficulties of construction remain to be disposed of. But so far as the author can see, they are no more serious than those commonly met in developing a new process.

The Largest Reinforced Concrete Bridge in America

A Viaduct with a Clear Span of Over 300 Feet

By Frank C. Perkins

The accompanying illustration shows the construction of the Larimer Avenue bridge at Pittsburgh, Pa., which is said to be the largest reinforced concrete arch bridge in America. It has a clear span of 300 feet 4 inches.

This reinforced concrete bridge replaced a combination of wood and iron viaduct that was built in 1891 and 1892, consisting of 60-foot spans on wooden towers.

Falsework for the Main Arch Rib.

The length over all of the bridge is 670 feet. It is 50 feet in width, with two sidewalks each 10 feet wide, and is 110 feet above the ground. It was designed and constructed under the supervision of J. G. Armstrong, director of the Bureau of Construction of the Department of Public Works of Pittsburgh.

The main arch consists of two arch ribs, and a reinforced concrete beam, and slab floor, supported by panel piers from the main arch rib. The arches are approximately parabolic form, and consist of two parallel ribs, having a uniform width of 8 feet spaced 30 feet center to center. They have a varying depth from 6 feet 6 inches at the crown to 11 feet at the springing line. They are braced together by struts spaced 19 feet 6 inches center to center. The rise from the springing line to the summit of the arch at the center line is 67 feet ½ inch. The approaches on either side of the main span consist of semi-circular arches spanning 30 feet center to center and 25 feet in the clear, and a reinforced concrete beam and slab floor.

The falsework for the main arch ribs shown in one of our illustrations consisted of 251,815 board feet of long leaf yellow pine. All forms were built of ⅞ inch matched pine, and as far as possible were made up into panels. The studding was 2 by 6-inch material and braced by horizontal walings of 4 by 6 pine, spaced 4 feet center to center.

The concreting of the main arch rib was placed in individual sections. The lower section adjoining the main piers was poured monolithic with the lower base of the main piers. The two sections at the crown of each rib were poured first, then followed the lowest sections, and so on, working toward the top. The forms for the beam and floor system over the main arch, shown in our illustrations, were completed from end to end before concrete was placed. The concrete was then placed in sections 19 feet 6 inches long, starting in the center of the span and alternately working from the center toward the end on both sides of the arch.

The reinforcement of the main arch rib consists of large size steel angles, used extensively, each rib having a longitudinal framework of eight angles, 6 inches by 4 inches by ¾ inch, forming a deep lattice girder. The structure comprises a central I section girder of four angles, and at each corner of the rib section a single additional angle, the whole well connected by transverse flat bars.

The reinforcement consisted of Mueser diamond bars with the exception of the steel angles previously mentioned. Crushed limestone was used in the concrete for all parts of the bridge above the ground level and gravel in those sections below the ground. Universal Portland cement and Allegheny River sand were used throughout the whole bridge.

The pavement of the roadway of this bridge is of special interest. The roadway of the bridge is covered with a gravel fill on the concrete slab, 8 inches deep at the center and shading off to nothing at the curbs. A 6-inch layer of 1:3:6 concrete was placed over this, then a 1-inch binder and a 2-inch sheet of asphalt, bringing the final surface of the middle of the roadway 1-inch below the curb grade.

In order to provide for the expansion and contraction of the roadway, joints were located at the abutments, over the main piers and over the third spandrel column from the main piers. The Larimer Avenue arch is noteworthy for the very successful surface finish obtained upon it. The main surfaces everywhere were bush-hammered, giving the surface an excellent texture and very uniform color tone.

The construction plant is also of great interest and the principal feature of the plant installation was a cableway, with towers 60 feet high and four spans of 750 feet. The towers were placed on tracks and equipped with a 12 by 12 aerial dump cableway engine and an 8¼ by 10 compound gear special tower moving engine. The total yardage of the bridge amounted to 9,471 cubic yards of concrete, 71,178 square feet of bush-hammering, 892,540 pounds of reinforcement steel, and 2,233 square yards of pavement.

The Changing Cost of Living*

Comparative Measurements at Home and Abroad

By Prof. J. Pease Norton

The changing cost of living is a fundamental cause of many reactions in the complexes of social phenomena. In fact, it is probable that an economic interpretation of many important historical movements may be developed from future study of such events as possible effects of this probable fundamental cause of radical movements in human societies, such as extensive revolutions and even international wars.

Political economists, at any rate, should hold always before them the idea that mankind is subject first to the primary economic problems of self-maintenance. The changing cost of living is another phrase to denote in a civilized society this factor of relative self-maintenance which is so important in the study of the more primitive societies. Thus, on the side of the consumption of commodities, we may measure the changing cost of the primary necessities in terms of the prices of the markets.

With the development of markets and with the establishing of standard grades for leading commodities, it becomes possible to fix rather definitely comparative prices of all of the more important commodities. As a result, we may compare with a considerable degree of accuracy the fluctuations in the changing cost of living over a series of successive years. Of couers, the greater problem of constructing an index number of relative welfare which shall combine in some rational way the general concepts of the cost of living and of the average rates of income may lead eventually to many interesting conclusions, but this problem at the present time is extremely difficult.

In this paper, which is divided into three parts, I shall present, first, the results of original computations of two series of index numbers for American prices. Hitherto, the purpose of index numbers has been chiefly to measure the changing cost of living in order to compare the relative conditions of successive years for the same country.

In the second part of this paper, I have endeavored

* Address of the vice-president and chairman of Section I, American Association for the Advancement of Science, Cleveland, January 3rd, 1913. Published in *Science*.

to present some comparative measurements of the changing cost of living for various countries at the same time, and, incidentally, to devise an international index number, based on some index numbers of the United States, England and France. In the third part, it is interesting to consider briefly various remedies for the instability of the price level, and to inquire whether a society has not within its control indirect methods of reducing absolutely the cost of living, methods which may prove more fruitful than some of the direct methods which have been suggested from time to time in order to secure a relative rather than an absolute reduction.

It is unnecessary to present a technical description of my two series of index numbers for American prices which have been described in the *Quarterly Journal of Economics*,[1] and elsewhere.[2] Suffice it to state that the general method of the Sauerbeck system has been adopted along with certain modifications, some of which were suggested by Forbes and others occurred as practical necessities of the computation.

The two index numbers may be described as the averages of the percentages of the prices of fifty important commodities expressed in terms of the average prices of the years, 1890 to 1899, so that the average price level of the years 1890 to 1899 is the base or one hundred per cent. Two systems of weighting have been used. My first series follows Sauerbeck in the use of the simple arithmetical average. The second series was intended as an approximate continuation of the Dun index numbers which ended in 1907, and which have been published since 1910 as the Gibson index number. The same arbitrary weighting is used in the two series, although the Dun numbers were based on three hundred and fifty commodities and the Gibson on fifty leading commodities. Mitchell[3] has shown that my method of continuing the Dun numbers by using fifty primary commodities rather than three hundred and fifty commodities, many of which are derivative, produces an average difference on the basis of past years approximately of two per cent. The fifty commodities consist of the leading articles of commerce which are most capable of accurate grading.

In Table I[4] the relative weighting of the various

TABLE I.—SHOWING WEIGHTING OF GROUPS IN VARIOUS INDEX NUMBERS.

Groups of Commodities	Sauerbeck's English Index Number, Per Cent.	Norton's American Sauerbeck Number, Per Cent.	Norton's Gibson or Dun Number, Per Cent.	Bradstreet's Index Number, Per Cent.	Bureau of Labor Index Number, Per Cent.
Clothing..	42	44	50	37	26
Food......	18	18	18	10	29
Other......	40	38	32	53	45

groups, such as foods, clothing, minerals and other commodities, is presented in contrast for various index numbers, in order to suggest the cause of the slight differences which occur in the results reached by the various numbers.

The more heavily the food group is weighted, the more the total index number of all commodities tends to advance. This point will be discussed later in this paper. On the other hand, if a large weight is given to manufactured articles, which is the case in the United States Bureau of Labor index numbers, the tendency is to reduce the extent of advance. The group weighting influences the results more than the fluctuations of single commodities, because all commodities of the food group are in a large measure in competition through possible substitution by consumers. Table II, which is represented by diagram No. 1, discloses the annual averages for the period, 1890 to 1912. The first column contains the American Sauerbeck index number,[5] the second column the Dun and Gibson series, and the third column the Dun and Gibson series reduced to the same base as the American Sauerbeck which is the average price level of the years 1890 to 1899 as one hundred per cent. This table is represented graphically by diagram No. 1.

The annual average difference of the two index numbers is two per cent.

To summarize the general movements, a five year average table has been prepared (Table III). This table shows how little the weighting has influenced the results in the two series, because the weighting for the food group differs in the two numbers to a less extent than in the case of the other possible comparisons.

[1] *Quarterly Journal of Economics*, August, 1910.

[2] Pamphlets on Index Numbers, published by the Gibson Publishing Co., 1910-11.

[3] *Quarterly Journal of Economics*, November, 1910.

[4] "How Index Numbers are Made," by F. C. Croxton, *Journal of Commerce*, June 2nd, 1910, and Norton, "Weighting of Index Numbers," June 9th, 1910.

[5] Norton's "Lessons Suggested by the Experience of the French People and of the Bank of France," *Proceedings of the Academy of Political Science*, January, 1911.

It is clear that both series of index numbers agree rather closely in showing that we have been living in an era of a prolonged advance in the cost of living during the past fifteen years. In summary, using my American Sauerbeck index numbers, the price level of 1912 is some 59 per cent above the level of 1896.

TABLE II.—ANNUAL AVERAGES OF TWO INDEX NUMBERS FOR AMERICAN PRICES.

	American Sauerbeck Index Number	Dun or Gibson Index Number	Percentage Dun Index Number
1890	114	92	109
1891	114	96	113
1892	105	90	107
1893	105	91	108
1894	94	83	98
1895	94	82	97
1896	87	74	88
1897	89	73	87
1898	95	78	92
1899	103	85	101
1900	112	91	108
1901	109	92	109
1902	118	102	121
1903	115	100	118
1904	116	97	115
1905	118	98	116
1906	124	105	124
1907	132	110	130
1908	124	106	126
1909	133	112	133
1910	137	115	136
1911	130	109	129
1912	138	117	138

TABLE III.—SHOWING THE FLUCTUATIONS OF THE FIVE-YEAR AVERAGES OF THE TWO INDEX NUMBERS FOR AMERICAN PRICES.

	Dun-Gibson		Norton-Sauerbeck	
1890–94	107		106	
		— 14		— 12
1895–99	93		94	
		+ 21		+ 20
1900–04	114		114	
		+ 12		+ 12
1905–09	126		126	
		+ 8		+ 9
1910–12	134		135	

and compared with 1890, the percentage of advance is 21 per cent.

Such instability in the average price level is unfortunate, and, whether we attribute the causes solely to forces acting on commodities or to fluctuations in the gold standard or to both causes, the central fact remains that the instability of the price level has caused many hardships to our people.

Let us now construct two index numbers by splitting up the component groups into a food index number and an "other than food" index number, using the average prices of each group, respectively, as the two bases, one hundred per cent. The purpose is to discover the relative movements of the two groups, foods and other than foods, over a period of fifty years. Using the early Dun numbers, reduced to the new percentages, we may present a rough comparison, which, I think, throws light on the situation.

What has happened becomes obvious upon inspecting Table IV, which presents the conditions of the price levels of the two groups for selected years, during the period commencing in 1860 and ending in 1912.

The figure for July, 1912, is given as the last comparison.

From the average of the low years, 1896 and 1897 down to 1912, the food group has advanced 80 per cent and the "other than food" group 43 per cent. Thus, compared with the two low years, 1896 and 1897, foods have advanced nearly twice as much as other commodities. Consequently, the hardships experienced by the classes of the smaller incomes have been very

TABLE IV.—SHOWING THE FLUCTUATIONS OF THE FOOD INDEX IN CONTRAST WITH THE INDEX FOR OTHER COMMODITIES FOR SELECTED YEARS. 1860 TO 1912.

	Index Number for Foods	Index Number for Commodities Other than Foods
1860	145	155
1864	293	452
1870	195	200
1875	167	160
1880	138	155
1885	117	112
1888	126	112
1889	124	112

The above statistics are as of January 1.

1890	102	117
1891	121	107
1892	107	107
1893	110	107
1894	102	95
1895	100	95
1896	81	95
1897	83	88
1898	93	93
1899	100	102
1900	105	112
1901	105	114
1902	126	117
1903	117	119
1904	105	112
1905	112	121
1906	119	131

The above statistics are as of July 1.

1907	121	140
1908	129	124
1909	140	126
1910	140	133
1911	136	124

The above statistics are annual averages.

1912	148	131

great throughout the world, inasmuch as in all family budgets the percentage spent for foods increases as income diminishes.

But, if we take as representative the figures of 1860 and 1880, leaving out of account the years of the civil war and of suspension of specie payments, we have 142 for foods and 155 for other commodities. Comparing the conditions of the years 1860 and 1880 with the low years 1896 and 1897, we might have said in 1896 and 1897 that foods had fallen 60 points and other commodities 63 points, or turning the comparison about, food prices as well as other commodities in 1860 and in 1880 were approximately 70 per cent higher in 1860 and in 1880 than in 1896 and 1897. In short, food prices are now on the level of 1860 and 1880 and other than food prices are probably 15 per cent lower.

In summary, since food prices during the past fifteen years have advanced in the United States nearly twice as much as the "other than food" commodities, it is unlikely that the tariff has played so important a part as other causes. Possibly, the tariff is indirectly responsible to some extent in over-stimulating industries of the "other than food" group, and in this way helps to contribute to a deficit proportion of agricultural population.

It seems more probable, however, that the great drop in prices which occurred from 1880 to 1896 represents in part the effects of the unprecedented railroad construction of those days and of the utilization of new inventions in farm machinery, two causes which were at work and must have cheapened the average cost of production of the food group. Naturally, rural population was displaced by farm machinery and we know that thousands of acres of farm lands in the East were rendered of less value by the falling prices, resulting from the application of these two great lines of inventions. As food prices fell and immigration continued on a large scale the wage rates fell, and reduced wages made the cost of production of other commodities lower and naturally the prices went down in sympathy with the lower cost of production.

Food prices are fundamental and "other than food" commodities are derivative through the wage scales which vary with the cost of food. Further, all statistics indicate a steady drift of population away from the food industries to the "other than food" industries,

suggesting that the opportunity to secure steady work by labor less securely attached to land has been better in the "other than food" industries.

The various movements to extend agricultural credit, to improve systems of distribution and to furnish instruction to the agricultural classes are doubtless in the right direction. But, it is difficult to see how these movements, beneficial as they may prove, can much more than keep pace with similar movements making urban work more productive, such as rapid transportation, trade schools, night schools, etc. In fact, the simple economic force to increase the relative production of foods is, after all, a continued higher level of food prices which will tend to raise farm wages and to stimulate increased production generally in all of the land pursuits.

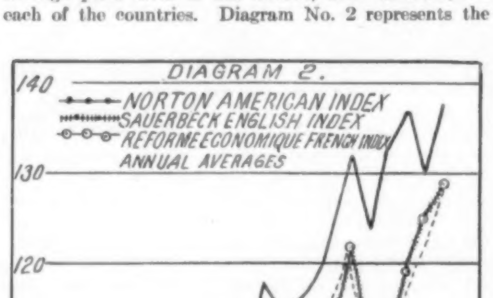
We come now to the second part of this paper, the comparative measurements of the changing cost of living, geographically considered. In Table V, illustrated

TABLE V.—SHOWING INDEX NUMBERS OF THE UNITED STATES, ENGLAND AND FRANCE.

	United States Norton Sauerbeck	England Sauerbeck	France Reforme Economique	Norton International
1890	114	109	109	111
1891	114	109	109	111
1892	105	103	103	104
1893	105	103	107	105
1894	94	95	98	96
1895	94	94	92	93
1896	87	92	90	90
1897	89	94	91	91
1898	95	97	96	96
1899	103	103	105	104
1900	112	114	112	113
1901	109	106	105	107
1902	118	105	103	109
1903	115	105	105	108
1904	116	106	104	109
1905	118	109	105	111
1906	124	117	115	119
1907	132	121	122	125
1908	124	112	111	116
1909	133	112	112	119
1910	137	118	119	125
1911	130	121	125	125
1912	138[7]	129[7]	129[7]	132[7]

by diagram No. 2, we may contrast the changing cost of living in the United States, England and France.

In order to make comparisons, Sauerbeck's index number for England and the index number[6] for France are reduced to percentages of their own averages for the years, 1890 to 1899, respectively. Thus, the three numbers for each year are simply percentages of the average price level of the decade, 1890 to 1899, for each of the countries. Diagram No. 2 represents the



fluctuations of the index numbers of the three countries.

This method affords a system of comparative measurements of the changing cost of living for different countries, but does not necessarily afford a basis for the measurement of the absolute cost of living in different countries. The latter is, also, an important problem which should be undertaken, the solution of which will require patient critical work in the determination of equal grades of commodities in various countries.

The fourth column contains the records of my international index number which is simply the average of the three preceding numbers for each year. It is interesting to note that American prices, commencing in 1902, advanced much more rapidly than did the price levels of foreign countries, but in the years 1911 and 1912 the margin of difference was considerably reduced.

We are led by our system of comparative measurements of the changing cost of living to the conclusion that world-wide causes are primarily responsible for the prolonged advance in the cost of living. It is probable that accurate statistics would show for India, China, the Argentine, in fact, for all countries of the world which are connected by commercial relations, quite similar conditions. My international index number for 1912 shows an advance of 46 per cent over the low year 1896, in comparison with 59 per cent for the United States, 40 per cent for England and 43 per cent for France. It should be noted that the United States numbers have advanced considerably more than the index numbers of foreign countries. But we should remember that commodities "other than food" advanced 49 per cent in the United States, which is on a parity with the advances of all commodities for England and France.

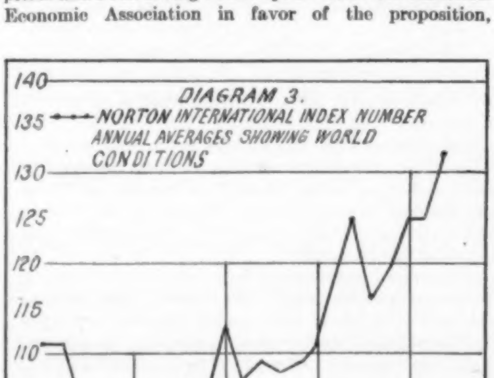
TABLE VI.—AFFORDING COMPARISONS OF 1896 AND 1912, AND 1880 AND 1912.

	Advance 1896-1912, Per Cent.	Advance 1880-1912, Per Cent.
United States, foods	83	7
United States, other than foods	49	—15
United States, all groups	59	— 6
England, all groups	40	— 3
France, all groups	43	

The extraordinary advance occurs in the food group of the United States, and it is quite possible that this represents several causes, some of which are technical, some of which are national and some are connected with the chain of sequences produced by an increasing production of gold. It is plain that international causes are at work. During sixteen years following 1880, world prices fell, and during sixteen years following 1896, world prices rose. It is interesting to note that independent computations show that after thirty-two years prices in the United States and in England have recovered very nearly the entire amount of the decline which reached the low point in 1896, and that now world prices are upon an approximate parity with those of 1880.

An excellent opportunity is afforded the recently appointed Industrial Commission to determine the rates of wages prevailing in 1912 in comparison with 1880, because the cost of living conditions in the two years are very much alike and the years are far enough apart in time to furnish an excellent basis for sound conclusions regarding the relative rates of income of all classes of labor. The results would probably surprise those economists who distrust the possibilities of social progress.

In 1907, the writer proposed the appointment of an international commission[8] to study the causes of the advancing price level, believing international causes were chiefly responsible. In 1912, as a result of the Washington meetings, when Senator Burton, vice-president of the American Association for the Advancement of Science, read a paper on the causes of the high prices and Prof. Irving Fisher spoke before the American Economic Association in favor of the proposition, President Taft finally recommended this plan to Congress. Endorsements have been given by resolutions of the New York Chamber of Commerce and more recently by the International Congress of Chambers of Commerce of the world. The Sulzer bill, providing for such a commission, is now before Congress.



The work of such an international commission on the cost of living might well include the computation of a series of identical numbers for the principal countries of the world. Such index numbers should disclose the absolute as well as the relative changing cost of living as measured by fifty to one hundred leading commodities, by providing for identical commodities, identical grades and identical weighting. Such an investigation is quite as proper for the Carnegie Institution or for the United States Bureau of Standards to undertake, inasmuch as such measurements of price levels are not only very central, but also pressing problems of economic research.

If a complete and thorough investigation should be undertaken to show the relations of the price movements of the principal countries, it is probable that the composite result expressed in the form of an international index number would not differ greatly from my international index number in statistical significance. The international index number is represented by diagram No. 3.

What would this result mean? I think that we should have in a well-defined form an approximation to those two concepts concerning which Jevons wrote, namely, first, an international multiple standard of value, and, second, a method of achieving the use of international money by making the present currency of all nations token money under the new standard of value.

Since we hold that the evidence shows that international causes are largely responsible for the advance in prices, we may omit consideration of many of the remedies which have been proposed from time to time which, if applied, would be essentially local in their operation.

What are the international causes which could have produced this common rise of more than forty per cent since 1896 in three countries, and what could have been the common international causes for the fall in prices of the period, 1860 to 1896? The writer believes that the international causes are three in number. First, cheaper transportation was responsible for a part of the decline, 1880 to 1896, and the cessation of railroad building on a large scale coupled with increasing consumption resulted in the recovery following 1896 in some part. Second, extensive use of farm machinery lowered the cost of production throughout the world and the use of labor-saving machinery on farms resulted in a relative displacement of farm labor, causing the relative exodus from the agricultural occupations. This caused a part of the decline in food prices down to 1896. Table VII, showing averages of food prices in

TABLE VII.—SHOWING FIVE-YEAR AVERAGES OF FOOD INDEX AND "OTHER THAN" FOOD INDEX.

1880 and 1885	128		124	
		— 3		—12
1888 and 1889	125		112	
		—17		— 5
1890–94	108		107	
		—17		—12
1895–99	91		95	
		22		21
1900–04	113		116	
		11		— 8
1905–09	124		108	
		17		21
1910–12	141		129	

comparison with the prices of other commodities indicates what have been the changes in the two groups by five-year periods. Diagram No. 4 discloses the trend of these averages.

Naturally, lower prices for foods resulting from cheaper transportation and the displacement of farm labor by agricultural machinery resulted in a world-wide relative urban movement. Undoubtedly, several years of continued high food prices will prove the most efficient cause to encourage an increased production of foods. All legislation making agricultural credit available and affording opportunities to acquire land on favorable mortgage conditions will contribute to this end.

The third international cause is undoubtedly the increased production of gold[9] commencing in the late nineties. Just as excess of paper money in the civil war period inflated prices, so the excessive gold supplies have inflated international prices, and all credit devices economizing the use of gold have helped to

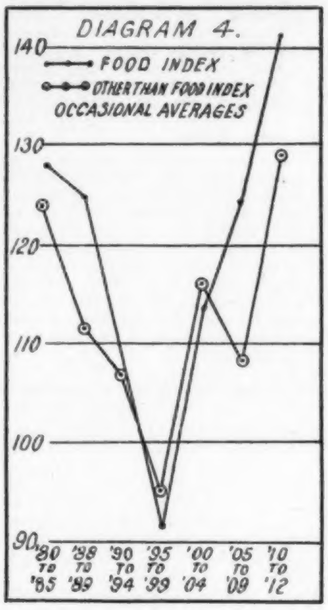
[6] Published monthly by *La Réforme Economique*.

[7] Average based on first ten months.

[8] *Yale Review*, 1906, and *Moody's Magazine*, 1907.

[9] Norton's "Good Food," *Cosmopolitan Magazine*, June, 1910.

magnify the tendency toward inflation. Possibly, the greater advance in food prices of the United States is due to the greater influences of the first two international causes in the United States, and the so-called



gold influence may be responsible for the larger part of the common advance. However, the relative importance of the three international causes may not be accurately estimated.

But the facts remain that the instability of the international price level is a disturbing element and the difficulty is that we measure all commodities in terms of one commodity rather than in the terms of fifty or more important commodities. In 1910, the writer recommended the establishment of an optional multiple standard,[10] possibly by the Bureau of Standards. In referring to this proposal, the Massachusetts Commission on the Cost of Living says:

"It is hard to see how any harm could come from giving official aid to the maintenance of such a standard for the use of any borrowers and lenders who chose to adopt it. In the event of a long continuance of the upward movement of prices, its use might prevent serious injustice and great hardship. We recommend that our senators and representatives consider the expediency of advocating its establishment."

The two classes which suffer most by the instability of the price level are wage earners and investors.[11] If wages were payable in the multiple standard, wages would fluctuate with cost of living and strikes would be diminished to a very great extent. If long time obligations were expressed in the multiple standard, creditors and debtors would exchange equal amounts of purchasing power. Now, all of these classes, the manufacturers, the labor unions, the bankers and the investors are intelligent. Why not leave the determination of the standard to agreement, and as a first step simply create an optional multiple standard which could be used when specified in wage contracts and in long time obligations.

The reasonable basis of an optional multiple standard would win its way and the economic benefits experienced would counsel its extension. By proper organization of clearing houses under a national clearing house,[12] by regulation of storage-warehouse warrants and the clearances of all classes of stock and produce exchanges, all transactions could be made either by the present currency made token money under a multiple standard, or by clearances direct in the optional multiple standard, since the holder of one unit of the optional multiple standard could convert into the value of any other commodity, if all prices were expressed in terms of the optional multiple standard, which involves simply a change of or a new definition of the dollar. This would be the final result, long anticipated by the economists. I quote from Patron's monograph on the Bank of France, prepared for the Monetary Commission:

"The interesting evolution of exchange which we are witnessing and which is familiar to everybody seems to be leading us, after the well-defined periods of barter and money, to a system of mere clearing of balances. All exchange operations would then be settled by simple book transfers. Coin reduced to money of account, would cease to play any real part. Economists are ever thinking of a return to barter, which would complete the cycle, bringing us back to the original state after thousands of years and combinations of all kinds. Such would be the course of this evolution."

But, as changes in monetary standards come very slowly, because men are unwilling to change the old landmarks without most careful investigations, we do not anticipate that the vision originally seen by Jevons will come to pass at once, even though the economists are again discussing this question after the lapse of many years.

If prices continue to mount actively, the agitation for such a change will occur with increasing force. But, we must remember, so far as the gold factor is concerned, that there are eastern nations with vast populations, capable of absorbing large quantities of gold under the stimulus of the western learning which is working as a yeast of progress among them. Further, we can steady prices and produce a declining tendency by requiring a larger proportion of gold in the reserves of the banks. This would at the same time strengthen the whole credit system. If we should go farther and require minimum flexible[13] reserves, higher in dull seasons and lower in active seasons, and incidentally higher on the average, as just suggested, a considerable fluctuating tendency would be eliminated.

After all, the Fabian policy lies before us, and looking ahead, it is probable that the agitation over this subject will be largely influenced by the course of commodity prices during the coming two years. This diagram discloses the quarterly fluctuations of my new international index number for the past five years. It is probable that we have passed the high point for two years or more, and that lower prices are now in order.

TABLE VIII.—MONTHLY INDEX NUMBERS—NORTON INTERNATIONAL SERIES.

	1907	1908	1909	1910	1911	1912
Jan. to March.......	125	117	116	125	124	129
April to June........	127	116	118	125	124	135
July to Sept..........	126	115	119	125	125	132
Oct. to Dec...........	122	115	121	123	126	

If this position shall turn out to be correct, we shall be in a better position two years from the present time to estimate whether the growth of population, the absorption of gold by eastern nations and the higher level of prices shall have overtaken the rate of increase of gold production sufficiently to produce an era of falling prices. When this occurs, as it will occur, sooner or later, we shall have the reverse agitation of the agricultural classes against falling prices such as our country witnessed in the Populistic agitations of the early nineties.

The money question, which has been a political issue, constantly changing in form and exceedingly disturbing to business, will continue to be with us so long as the instability of the price levels continues.

One result of the prolonged advance in the cost of living has been to emphasize the necessity of "economy," not only personal, but also "political," quite in the original sense of political economy. The very name of the movement which in a way is a constructive reaction from the economic stimulus of a lessened purchasing power is significant. I refer, of course, to the conservation movement. The word conservation, although vague, stands for the diminishing of wastes. In the conservation movement, we have a return to the original purposes of "political economy." The items which make up the cost of living as represented by an average family budget suggest plainly the directions in which the prevention of wastes may prove most fruitful. In the attempt to reduce the absolute cost of living, society wages an eternal warfare against the destructive wastes of nations,[14] which are preventable war, preventable ignorance, preventable sickness, whether physical, intellectual or moral, preventable death, preventable accidents to life and property, and preventable lack of opportunity which may delay or prevent the productivity of exceptional minds like those of Edison and Burbank, which exist in all degrees in certain proportions in the population. The last waste is the greatest waste which society still permits. The public school system is an institution created to furnish equal opportunity for education, but it is probable that a system of vocational guidance for exceptional children, i. e., above the average, would prove an extremely profitable policy for a nation to undertake on a large scale.

If we admit that in a population some are exceptional beyond others in intelligence, in foresight and in inventive capacity, and we know this to be true by the prevalence of idiots, insane persons, criminals and paupers, classes below the average, it follows that the larger population of the same strain, the greater will be the number of exceptional minds above the average. It is self-evident that the national dividend of a better civilization is created by the exceptional minds of a nation for the higher utility of all. We reduce absolutely, not relatively, the cost of living when we discover a cheaper method of controlling the matter and the forces of the world. Thus, a natural tendency to progress[15] is inherent in an increasing population, unless checked by the destructive wastes of nations. Nor can we overestimate the importance of ethical and hygienic standards in the study of political economy. Our measurements and standards of utility must be based on ethical and hygienic values rather than on conceptions of ophelimity or desirability.

By ethical standards, we mean to include among others the more enlightened conceptions of jurisprudence, and by hygienic standards the well-balanced judgments of enlightened medical and sanitary experts. But the guidance of present statistics of the cost of living supplemented by vital statistics is essential to a balanced judgment and the lack of accurate statistics on social and economic subjects is well known. Without measurements, our conclusions must be vague.

[10] Norton's "The Remedy for the High Prices," *Independent*, February 10th, 1910.

[11] Norton's "Stocks as an Investment when Prices are Rising," *Securities Review*, September, 1912.

[12] Norton's "Central Bank as a Federal Clearing House," *Moody's Magazine*, September, 1910.

[13] Norton's "Statistical Studies in New York Money Market," 1901.

[14] Norton's "Economic Advisability of a National Department of Health," *Journal of American Medical Association*, August, 1906.

[15] Norton's "Cause of Social Progress and the Rate of Interest," *Popular Science Monthly*, September, 1910.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

The Freezing Point of Mercury: An Interesting Coincidence

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

It is common knowledge that the freezing point of mercury is 40 degrees on the Fahrenheit scale, which at present is the most generally known scale in this country. But while those who are familiar with the Centigrade scale know that the freezing point of mercury is also 40 degrees on that scale, I have met no one who has noticed that the point, and the only point where the two scales agree is also the point at which an important natural phenomenon, the freezing of mercury, also occurs.

JOHN PHIN.

To find Triangles With Their Sides Proportional To Integral Numbers

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

I note that you take an interest in number work. It is sometimes convenient to find right-angled triangles whose sides are in integral ratios: as 3, 4, 5, the ratio numbers that are so much used in arithmetic, carpentering, etc. There are other right triangles in integral ratios that may be found by the formula $(a^2-b^2)^2+4\,a^2b^2=(a^2+b^2)^2$. In which put $a=2$, $b=1$, for example, which gives $9+16=25$; or the 3, 4, 5 right triangle. $a=3$, $b=2$, gives 5, 12, 13 right triangles; $a=3$, $b=1$, gives 8, 6, 10 right triangles; similar to the 3, 4, 5 right triangles. To avoid producing similar triangles, use a and b prime to each other and the one in the even and the other in the odd numbers. Thus: $a=4$, $b=3$, gives 7, 24, 25; $a=4$, $b=1$, gives 15, 8, 17; $a=5$, $b=4$, gives 9, 40, 41; $a=5$, $b=2$, gives 21, 20, 29; nearly an isosceles right triangle. If it is desired to approach to any particular form, find it in the ratio function $a{:}b$ as for the isosceles right triangle $a{:}b{::}5{:}2$ nearly; as, $a=12$, $b=5$, gives 119, 120, 169; or $a=29$, $b=12$, gives 697, 696, 985; or $a=70$, $b=29$, gives 4,059, 4,060, 5,741. It is evident we could approach any particular form with integral ratio as nearly as we please.

Nebraska City, Neb. IRA J. PADDOCK.

Efficiency of Eiffel Surfaces

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

As a matter of record, may I correct an inaccuracy in the table of figures accompanying my article on the "Comparative Efficiency of Eiffel Surfaces" in the SUPPLEMENT for May 17th? In the fourth and fifth lines of the table Kx and Ky should read Rx and Ry, and the numbers following these terms should be whole numbers and not fractions, thus: 243, 297, etc.; 1,494, 1,512, etc.

It may interest readers of my article to know that I have received the following comment from M. Eiffel's laboratory in Paris: "The ratio $\frac{Ry^2}{HP}$ that you propose for characterizing (the efficiency of) aeroplanes is undoubtedly of great interest and may very well be used for this purpose."

Brookline, Mass. ROBERT D. ANDREWS.

NEW BOOKS, ETC.

Handbuch fuer Heer und Flotte. Enzyklopädie der Kriegswissenschaften und verwandter Gebiete. Herausgegeben von Georg von Alten, Generalleutnant z. D. Fortgeführt von Hans von Albert, Hauptmann a. D. Unter Mitwirkung von mähr als 300 der bedeutendsten Fachautoritäten. Berlin: Deutsches Verlagshaus Bong & Co., 1913.

The history of the Hohenzollerns and Hohenstaufens are the principal topics discussed in installments 57, 58, 59, and 60 of the "Handbuch für Heer und Flotte." Prof. Dr. Bitterauf dwells on the historical significance of the Hohenzollerns as electoral Princes of Brandenburg, Kings of Prussia, and German Emperors. Numerous individual articles describe the careers of military members of the house. Much stress is naturally laid upon Friedrich Wilhelm, the great electoral prince, who laid the foundation of Hohenzollern military supremacy, and on Friedrich Wilhelm I, who wielded the sword of his predecessors so mightily and whose prudence made it possible for Frederick the Great to elevate Prussia to the dignity of a world power. Prof. Dr. Hintze has drawn a very interesting picture of Frederick the Great's activities, and has shown what the Silesian and the seven years' wars meant for Prussia, and how Frederick the Great made his kingdom one of the most respected in its day. Major-General von Voss takes up the subject of the Napoleonic wars and the wars of independence in his biography of Friedrich Wilhelm III.

The article on the Hohenstaufens takes the reader back into the twelfth century; in a word to the time from 1138 to 1254 when this famous Swabian house was enthroned.

The installments before us, like those which have preceded it, are richly illustrated.

Origin and Antiquity of Man. By G. Frederick Wright, D.D., LL.D., F.G.S.A. Oberlin, Ohio: Bibliotheca Sacra Company, 1912. 8vo.; 547 pp.; illustrated. Price, $2 net.

Those who have read the author's "Ice Age in North America," or "Man and the Glacial Period," will doubtless follow with as great interest this fresh presentation and interpretation of whatever knowledge is ours concerning the Glacial epoch. It will be remembered that Dr. Wright places a much more moderate estimate upon the antiquity of man than do many of his fellow-investigators, and his effort is to make physical evidence and scriptural statement coincide, reserving to himself the right to "properly interpret" the latter. His conclusion is that "post-glacial time is to be reckoned by thousands of years, rather than by hundreds of thousands, or even tens of thousands." The Glacial period has been the author's chief study for forty years, and his depth of knowledge and keenness of perception in regard to this epoch are undeniable.

Radium and Radioactivity. By A. T. Cameron, M.A., B.Sc. New York: E. S. Gorham, 1912. 12mo.; 185 pp.

The more important facts of this new branch of science are brought together within the covers of this little volume, and an effort has been made to present them in such manner that the reader need have but a very elementary knowledge of physics and chemistry in order to appreciate them. The production of energy in radioactive changes is followed, from the time heat as an accompaniment of such changes was noticed by MM. Curie and Laborde to the more recent experiments and conclusions of the present day. The transmutation of elements is made the subject of another informing chapter, and the practical application of radium in medicine is cited, with its effects upon the skin and upon ulcerous growths.

Engineering of Shops and Factories. By Henry Grattan Tyrrell, C.E. New York: McGraw-Hill Book Company, 1912. 8vo.; 399 pp.; illustrated. Price, $4 net

In contrast to our indifference of a few years ago we are now fairly alive to the advantages of a well-planned shop or factory with its scientific installment of equipment, and it is hardly possible to expend too much thought upon these considerations when contemplating new construction. We have already favorably mentioned the author's work on "Mill Buildings," and the present volume is intended to supplement that work rather than to be in itself complete and exhaustive.

A Handbook of Incandescent Lamp Illumination. Schenectady, N. Y.: General Electric Company, 1913. Price, 50 cents.

The contents of this vest-pocket guide are so varied that it would take too much space even to indicate their scope with any justice, but it may be said that besides many useful laws, formulæ and calculations, there are short articles on train lighting, sign lighting and street lighting, with suggestions and recommendations of distinct value.

An Introduction to the Mathematical Theory of Heat Condition. With Engineering and Geological Applications. By L. R. Ingersoll and O. J. Zobel. New York: Ginn & Co., 1913. 8vo.; 171 pp. Price, $1.60.

Suggestions from engineers in various lines of work, combined with the pedagogic experience of the authors, have gone to the making of this textbook. It pays especial attention to the needs of the student who lacks time and mathematical preparation to pursue the study at great length, pointing out more clearly than has hitherto been done the applications of which the results are susceptible, and it treats of problems that interest the geologist and the engineer.

Electricity and Magnetism. For Students in Engineering. By Robert Harbison Hough, Ph D. and Walter Martinus Boehm., New York: The Macmillan Company, 1913. 12mo.; 233 pp. Price, $1.10 net.

The more important numerical relations existing among the principal quantities employed in electricity and magnetism are developed by the text in logical order from definitions and simple laws. The text is designed for use with lecture demonstrations, and no descriptive matter is furnished.

Magnetism and Electricity. A Manual for Students in Advanced Classes By E. E. Brooks, B.Sc., and A. W. Poyser, M.A. New York: Longmans & Co., 1912. 8vo.; 633 pp.; 413 illustrations Price, $2 net.

Before specializing in any branch of electrical engineering, it is necessary for the student to acquire a certain amount of general knowledge. This general knowledge the authors of "Magnetism and Electricity" aim to give. The manual sets forth the principles of electrostatics, magnetism and voltaic electricity, supporting its statements with simple experiments, and fixing its teaching in the mind of the student by exercises, the answers to which are given in the back of the book.

Electricity. By Gisbert Kapp. New York: Henry Holt & Co. 16mo.; 256 pp. Price, 50 cents net; by mail, 56 cents.

The Home University Library of Modern Knowledge would scarcely be complete without a volume on the subject of electricity. Prof. Kapp has succeeded in writing a very acceptable simple explanation of the laws and dynamics of electrical energy, with a final chapter on its commercial and industrial distribution.

Wireless Telegraphy and Telephony. By William J. White, A.M.I.E.E. New York: Whittaker & Co., 1912. 12mo.; 202 pp.; 100 illustrations. Price, $1 net.

"Wireless Telegraphy and Telephony" was first issued in 1906, but this second edition appears in a revised and enlarged form. It is addressed to the general reader, and sets forth the principles and practice of the latest methods in wireless transmission.

The Metric System in All Its Details. Compared with the American Weights and Measures. By Henry G. Bayer. New York: Henry G. Bayer. 16mo.; 94 pp.; illustrated.

The Metric System in a Nutshell. And Twenty Tables of Equivalents. By Henry G. Bayer. New York: Henry G. Bayer. 31 pp.; pamphlet form.

"The Metric System in All Its Details" makes a strong plea for the general adoption of this system in place of the unwieldy, time-consuming and costly measures now in use. In logical arrangement and convenient form, it gives the metric measures of length, of surface, of volume, of capacity, of weight, and of value, each with adequate tables of equivalents. There is also a section devoted to miscellaneous measures, another to thermometers, and yet another to a table of old measures still in use in certain countries, with American equivalents. "The Metric System in a Nutshell" covers the same ground, but of course with much less detail.

Malaria. Cause and Control. By William B. Herms, M.A. New York: The Macmillan Company, 1913. 8vo.; 163 pp.; illustrated. Price, $1.50 net.

The mosquito is of course dealt with at length, and the modes of its extermination are thoroughly discussed. Internal medicines, the co-operation of the press, the preliminary survey, and the expense involved, are all points covered by the author. He holds that a successful campaign can be carried on at an expense of seventy-five cents a day per square mile, and that such a campaign has resulted in reducing malaria fifty per cent in the first season.

A Dictionary of Automobile Terms. By Albert L. Clough. New York: The Horseless Age Company, 1913. 8vo.; 357 pp.; illustrated.

The compiler has found more than fifteen hundred words and phrases appertaining to the automobile and its accessories and operations, and has listed them alphabetically with succinct paragraphs of description or explanation. The dictionary is freely illustrated.

A Course in General Chemistry. By William McPherson and William Edwards Henderson. New York: Ginn & Co., 1913. 8vo.; 556 pp.; illustrated. Price, $2.25.

This course, prepared by the authors of "An Elementary Study of Chemistry," makes no claim to novelty in method or arrangement unless it be in leaving the halogen elements for a relatively late consideration. It is more comprehensive than most textbooks of its kind, introducing historical paragraphs and presenting modern industrial processes when they aptly illustrate the principles at issue. By the historical touch it succeeds in humanizing abstractions that might otherwise find the student cold and unreceptive.

Radford's Architectural Drawing. Prepared under the Supervision of William A. Radford, assisted by Loring H. Provine, B.S., and Alfred S. Johnson, A.M., Ph.D. Chicago: The Radford Architectural Company. 8vo.; 344+86 pp.; illustrated.

Radford's Mechanical Drawing. Prepared under the Supervision of William A. Radford, assisted by Ervin Kenison, S.B., and Alfred S. Johnson, A.M., Ph.D. Chicago: The Radford Architectural Company, 1912.

In the artificial world which has become so much a part of our environment, the importance of drafting can scarcely be overestimated. It must be resorted to before any achievement in creative industry can be realized. The authors of these volumes have particularly had in mind the needs of the ambitious man studying alone. The works can be mastered without recourse to outside aids.

Bi-sexual Man, or the Evolution of the Sexes. By Buzzacott and Wymore Chicago: M. A. Donohue & Co., 1912. 8vo.; 83 pp.; illustrated.

According to its authors, this slim volume is but the foreword to a projected literature of a theory of degeneration, as opposed to the theory of evolution. In brief, the sexes are conceived of as having descended from original androgynous ancestry. Evidence contrary to their theory has been ignored.

Methods of Organic Analysis. By Henry C. Sherman, Ph.D. New York: The Macmillan Company, 1912. 8vo.; 407 pp. Price, $2.40 net.

This is the second edition of a work that has been successfully used in classroom and laboratory for more than six years. Some new matter has been incorporated—chiefly concerning solid and liquid fuels, industrial alcohol, drying oils, methods of glycerin analysis, and quantitative methods for testing enzymes. As a whole, the text furnishes adequate introductory training in organic analysis, with emphasis on plant and animal substances and their manufactured products.

Lackey's Wonderful Profit-marking Tables. Chicago: Park R. Lackey, 1912. Price, $5.

These ingenious tables give their information at a glance, without any figuring, thus saving considerable expenditure in time, energy and money. Given the cost of one article—or of a dozen or a gross—with the profit desired, and these two factors, cost and desired profit, indicate the column in which the necessary selling price is given.

Flag Day. Its History, Origin and Celebration as Related in Song and Story. Edited by Robert Haven Schauffler. New York: Moffat, Yard & Co., 1912. 12mo.; 225 pp. Price, $1 net.

Parents, teachers and children all have difficulty in finding suitable orations and recitations for certain of our American holidays. In "Flag Day" will be found many of the best poems and short prose utterances bearing upon our flag, its meaning and its influences.

The Metropolitan Automobile Guide. A Selection of Short Trips from New York to Nearby Shore, Hill and Lake Resorts. Grouped According to Length into Six Sections. Compiled by Henry MacNair. New York: The Automobile Blue Book Publishing Company, 1912 8vo.; 547 pp.

The maps, directions and descriptions are substantially bound in black leather. A general index map gives all routes and the principal cities, while section index maps show each route in a separate color. Street maps of cities and towns show the entrances and exits to nearly a hundred places in New York, New Jersey and Connecticut, and illustrations of interesting points abound.

Independence Day. Its Celebration, Spirit, and Significance as Related in Prose and Verse. Edited by Robert Haven Schauffler. New York: Moffat, Yard & Co., 1912. 12mo.; 318 pp. Price, $1 net.

"Independence Day" places much emphasis upon safety and sanity, discouraging the old noisy and dangerous methods of celebrating the day, and offering in their place gatherings for the inculcation of true patriotism and understanding love of country; martial music and inspiring military displays; orations; and simple, wholesome banquets.

Theoretical and Physical Chemistry. By S. Lawrence Bigelow, Ph.D. New York: The Century Company, 1912. 8vo.; 544 pp.; illustrated. Price, $3.

The work here given us may be advantageously used, either as a basis for two or three lectures a week throughout the year, or for shorter courses or collateral reading. Prof. Bigelow deplores the prevalent impression that very advanced mathematics are necessary to a good understanding of physical chemistry, and in his present work there are but a half-dozen demonstrations where arithmetic and elementary algebra are insufficient to clearly demonstrate the propositions.

Old Paris. Its Social, Historical, and Literary Associations. Including an Account of the Famous Cabarets, Hotels, Cafés, Salons, Clubs, Pleasure Gardens, Fairs and Fêtes, and the Theaters of the French Capital in Bygone Times. By Henry C. Shelley. Boston: L. C. Page & Co., 1912. 8vo.; 354 pp.; illustrated. Price, $3 net.

The fifty illustrations are from rare prints furnished by the British Museum and the Carnavalet Musée, and will create the most pleasurable emotion in those who appreciate such souvenirs of bygone days. As to the text, it is only necessary to say that Mr. Shelley has succeeded in reproducing for us that sparkle, that effervescence, for which Parisian life has so long stood, and has succeeded in no common degree. Paris has long been a lodestone for pleasure-seeker and philosopher alike, and the impressions of the most famous of its visitors are given us, as well as the rhapsodies of its native sons.

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Table of Contents